CHLORIDE OF LIME
IN
SANITATION

BY

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PREFACE

ON THE advice of Dr. L. H. Baekeland, President of the American Institute of Chemical Engineers, and chemical counsel of the Hooker Electrochemical Company, the research department of the latter company undertook to collect all data relating to the uses of chloride of lime in sanitation.

An unexpectedly large amount of important information was thus obtained, and the fact was clearly revealed that this inexpensive chemical was one of the most valuable and economical agents available for the protection, in many ways, of the public health.

It, therefore, seemed almost a duty to place before sanitarians and those in charge of work connected with public health, the information brought together, all of which is not readily accessible. Hence this book was written.

Instead of presenting a dry enumeration of bibliographical abstracts, it was thought preferable to offer the subject in a somewhat more connected form in several chapters, each dealing with a different problem of sanitation.

The reader who desires more information may find it in the chapter of abstracts where subjects can be traced further to the original sources of information.

I desire to express my thanks for the valuable aid received from Mr. O. C. Hagemann, who was employed for collecting the bibliographical references, and to Dr. Baekeland, whose continuous advice and assistance inspired our enthusiasm to publish this work.

ALBERT H. HOOKER,

Niagara Falls, N. Y., August, 1912.

CHLORIDE OF LIME.

FEW elements are more widely distributed than chlorine. We find it in combination with the metal sodium as chloride of sodium, or common salt, in inexhaustible quantities in sea-water, or as large mineral deposits of rock salt. Its very presence in our blood seems to be a physiological necessity. Yet the discovery of this element is of relatively recent date.

We owe the discovery of chlorine to the famous Swedish chemist, Scheele, born in 1842. It is a heavy gas, of green color, and of very corrosive properties. It attacks violently metals and organic bodies. It is soluble in water and gives a greenish solution of irritating smell, which soon decomposes, specially when exposed to light. The gas can be liquefied by compressing it in special machines. If care be taken to exclude all moisture, this liquefied chlorine can be kept and transported in strong steel cylinders and has become a commercial article, which is now manufactured in the United States as well as in other countries, like Germany.

Berthollet, the French chemist, in 1785, as the result of careful investigations, declared chlorine to be an *oxygenated muriatic acid* (acide muriatique oxygen). But it was not until 1810 that Sir Humphry Davy definitely showed chlorine to be a chemical element, and not a compound. He gave it the name chlorine from the Greek $\chi\lambda o\rho o\varsigma$ = green.

In the early days, after Berthollet observed that chlorine gas possessed the remarkable property of destroying the color of vegetable substances with which it came in contact, he happened to have with him as a visitor, a young Englishman, no less a personage than James Watt, to whom he showed the bleached articles. Watt was deeply impressed, and at once thought of his Scotch home, where his father-in-law was engaged in a large way in the time-honored staple industry of linen bleaching which for centuries had given character to wide stretches of rural Scotland.

The Scotch bleachers never had been able to attain a perfect degree of whiteness. In fact it was customary to send the goods to Holland and Flanders, where a highly lucrative but conservative industry flourished, based on a finishing process in which the use of buttermilk seemed indispensable.

The costly white linen thus obtained (the term "Hollands" remains to this day) was shipped back to Leith, the trade center for this staple. Watt induced his father-in-law to make a trial with chlorine, which he did with about 1500 yards of linen.

The immediate results astonished everybody, but were soon turned into disappointment, after the chlorine attacked the fiber, and the linen rotted until it was entirely spoiled. Jeers then came down upon the young enthusiast from every side of a circle dominated by the prejudices of trade habits.

Watt undertook another journey to Paris, and Berthollet contrived a remedy: he neutralized the obnoxious properties of chlorine gas by absorbing it first into a solution of alkali.

Chlorine bleaching had now become feasible, though the high cost of the chemicals still marred its commercial success. Soda, which can be bought today at less than a cent a pound, in a state of purity of about 99%, then only existed in a crude 20% form called *Barilla*, made from sea weeds, for which 13 cents per pound was charged.

But the right man, Dr. Henry, took hold of the problem. He substituted milk of lime for the expensive alkali and after twelve years of clever and tenacious labor, succeeded in converting the powerful chlorine gas into a dry-portable, handy form, containing 35% efficient chlorine, by combining it with *slaked lime*, thus making so-called "chloride of lime." Chloride of lime is known also as "Bleach," "Bleaching Powder," "Hypochlorite of Lime," etc.

In 1799 Charles Tennant of Glasgow, was granted a patent for it, and for 100 years this trade has been developed and held where it took its origin, *in England.* In 1910 Great Britain produced 110,000 tons. The industrial use of chloride of lime, dates from about the year 1800. An interesting comparison of the amount manufactured and the price per ton is given by Mactear as follows:

1799–1800	52	tons	@	$680.00	per	ton.
1805	147	"	@	545.00	"	"
1820	333	"	@	292.00	"	"
1825	910	"	@	131.00	"	"
1870	925	"	@	41.50	"	"

The production of chlorine was of necessity intimately linked to the soda industry, or Leblanc process, because the initial raw material, common salt, or sodium chloride, is the same for both, or to put it more correctly from the muriatic acid produced obtained in the Leblanc-soda process.

As early as 1825, chloride of lime was made from the recovered muriatic acid of the alkali plants. The greatest development of the production of chloride of lime dates from the introduction of the British Alkali Act about 1865, when the soda manufacturers were compelled to cease discharging large volumes of hydrochloric (muriatic) acid vapors into the air, or condensed acid into the streams. The available outlet for this bothersome by-product was the manufacture of chloride of lime; hence the development of a market for its use. From this act to prevent a nuisance has grown up a great industry which now gives us not only an unusually efficient material for bleaching paper and textiles, but also the most economical and efficient disinfectant and deodorizing agent known.

England's enormous alkali trade reached its zenith about 1880, when she exported of alkalis 349,000 tons, of chloride of lime 71,600 tons.

At that time (1880) the United States produced:

Alkalis, 18,200 tons.

Chloride of lime, none!

United States imports in 1880 were:

Alkalis, 166,400 tons.

Chloride of lime, 34,000 tons.

Be it understood that, inasmuch as the market for chloride of lime was much more limited than the demand for alkalis, a large portion of the chlorine material (hydrochloric or muriatic acid) obtained in the decomposition of salt for the Leblanc process, had to be wasted.

Meanwhile, a new method for making soda from salt (sodium

chloride) and ammonia, the "Ammonia Soda process," or Solvay process, had sprung up, and developed with gigantic strides; but this process gives no chlorine or chloride of lime as by-product.

The pace kept by the two rivals may be followed from the following world's production figures of soda (caustic and carbonate):

		1850	*1865*	*1870*	*1875*
Old Leblanc process, tons		165,000	413,000	463,000	495,000
Ammonia (Solvay) process	"	....	330	2,860	33,000
		1880	*1885*	*1890*	*1895*
Leblanc process	"	546,000	436,000	391,000	447,000
Ammonia (Solvay) process	"	137,000	368,000	634,000	987,000

The Leblanc industry, threatened with ruin, however, held its own on account of the ever growing demand for chloride of lime, of which it remained the sole purveyor.

British exports during 1890 rose to 89,000 tons and within the following two years, the so-called British Alkali Trust advanced the price for chloride of lime by 40%. But a new rival was soon to appear, and from the year 1890 dates the installation of the first electrolytic works, for the electric production of alkali and chlorine with 400 electric horsepower, by what is usually known as the "Griesheim-Electron" concern in Frankfort, Germany. The plant was doubled in 1892, and redoubled to 1600 horsepower in 1894.

To the layman's conception, we could not more forcibly present the singular efficiency and advantages of electrolytic methods, than by stating that by means of an electric current, sodium chloride, or common salt, is split into its constitutents, sodium and chlorine. The sodium reacts immediately on the water which is present and produces caustic soda. The chlorine is used for various purposes, but mainly for the manufacture of chloride of lime. This is done by bringing the chlorine gas in contact with slaked lime (hydroxide of calcium). This operation is carried on by conducting the chlorine in large chambers in which the slaked lime is spread in thin layers so as to facilitate

absorption. The resulting bleaching powder, or chloride of lime, is then packed in barrels, as is done in Europe, or better in steel drums containing about 800 lbs. each, as is done in the United States. The electrolytic chloride of lime manufactured in the United States now contains generally 36%–39% of available chlorine, while the European product usually contains only 35% or less.

In the Leblanc and the Solvay processes for the manufacture of carbonate of sodium, or soda ash, the results are brought about in a much more indirect way than in the electrolytic processes; those older processes use several complicated steps in which a number of other chemicals are used, and made to act upon the common salt, and the intermediary products into which the sodium chloride is being successively converted.

It is only through the monumental efficiency evolved in the recovery and re-use of these auxiliary chemical agents, that an ammonia-soda industry, producing annually 2,400,000 tons of soda-ash (sodium carbonate) can exist.

Following up the success won by Griesheim Electron, came into existence a large number of electrolytic works, first in Germany: at Bitterfeld in 1894, 3,000 horsepower, at Rheinfelden in 1896, 3,500 horsepower, and further on extending to other countries, more specially in the United States where at this moment more than 30,000 electric horsepower are used daily in its production. There is an intense competition in the manufacture of this article and many electrolytic manufacturing establishments started here and abroad with large outlay of money have resulted in dire failure; only some of the better equipped and better conducted plants have survived.

At present (1912), the world's production of chloride of lime approximates 400,000 metric tons (1,000 kilos or 2,200 lbs.) with statistics for 1910 showing:

Great Britain	metric	tons	110,000
Germany	"	"	90,000
United States America	"	"	80,000
France and Belgium	"	"	40,000
Austria, Italy, Spain	"	"	30,000
Russia	"	"	22,000

The United States started making chloride of lime in 1895; the singular progress made since in production, as the importance to which this article has risen as a technical factor, may be judged from the following figures:

United States Imports and Production of Chloride of Lime. Metric Tons.

	1850	*1855*	*1860*	*1865*	*1870*	*1875*
Imports	2,810	4,560	7,850	10,500	10,500	22,000
Production	......	......	......	......	......	......

	1880	*1885*	*1890*	*1895*	*1900*
Imports	34,000	43,300	45,100	45,600	61,900
Production	......	......	......	......	10,000

	1905	*1910*
Imports	43,600	42,600
Production	17,800	81,000

Electrochemistry seems to have decreed the doom of the venerable Leblanc process and in the meantime, the price of chloride of lime has been halved. England's annual exports have fallen to 50,800 tons, and the United States, though still importing heavily, supplies about two thirds of its own consumption. This home supply is furnished by several competing electrolytic plants.

The name "chloride of lime" given to the product by the earlier chemists who dealt with this product, suggested at once the notion, then predominant in the minds of the first investigators, that chlorine could chemically combine with lime in a simple manner.

A rational theory on its composition and constitution was first propounded in 1835, by Balard, who found it to be composed of

	Calcium hypochlorite......	$Ca(OCl)_2$
	Calcium chloride..........	$CaCl_2$
and	Calcium hydroxide........	$Ca(OH)_2$

Subsequent investigations by Olding and other chemists have shown that calcium chloride, as such, does not exist in bleaching powder, but is formed on dissolving the latter in water.

Accordingly, $CaOCl_2$, calcium oxychloride, is generally accepted to be the essential constituent of dry chloride of lime,

and to undergo in contact with water, the above mentioned change:

$$2CaOCl_2 = Ca(OCl)_2 + CaCl_2$$

$$\begin{array}{c}\text{Calcium}\\\text{oxychloride}\end{array} = \begin{array}{c}\text{Calcium}\\\text{hypochlorite}\end{array} + \begin{array}{c}\text{Calcium}\\\text{chloride}\end{array}$$

Chloride of lime is soluble in about twenty times its weight of water, leaving a small insoluble residue, mostly calcium hydrate. In an aqueous solution, calcium hypochlorite forms the only valuable constituent, the calcium chloride being inert and valueless.

It should be well understood that chloride of lime, in its industrial application of bleaching, deodorizing, or disinfecting, does not act by its chlorine, but by its oxygen. Its action is not "chlorination," but "oxidation." This simple axiomatic truth seems to have been overlooked by those who try to use chlorine instead of chloride of lime, and thus bring about endless complications, due to chlorination on account of the direct action of chlorine on organic bodies. From solutions of hypochlorites, carbonic acid contained in the air, or in water, or other dilute or weak acids, will liberate free hypochlorous acid; the latter in the active oxidizing agent of chloride of lime. Although it is such a weak acid that almost all other acids, however weak, may drive it out of chloride of lime, it is probably the most powerful oxidizing agent known to chemists.

It will give up nascent oxygen with extreme readiness: $2\ HOCl = 2HCl + 2O$, and therefore, when liberated in dilute solutions of chloride of lime by the minute quantities of carbonic acid ever present in water and air, it only can oxidize gradually, or as it were, in sections, the measure for each section being the carbonic acid temporarily available; this may explain why hypochlorites are the least wasteful oxidizing agents as well as in their "selective action" on organic bodies and bacteria, the less resistant ones making first claim on the ever limited amounts of nascent oxygen.

When free hypochlorous acid is brought in contact with hydrochloric (muriatic) acid, the constituents of both become promptly resolved into water and chlorine: $HClO + HCl = H_2O + 2\ Cl$.

For this reason, hydrochloric acid by itself, or such strong

acids as would evolve hydrochloric acid from the ever-present calcium chloride, must be avoided and weaker acids (acetic) are used in the arts for setting free hypochlorous acid in solutions of chloride of lime.

Chloride of lime is valued and sold on its percentage of "available chlorine," a term which indicates the whole amount of free chlorine that becomes available in decomposing chloride of lime by means of strong acid.

From preceding remarks, it must become clear that "available chlorine" is derived,

Half from the calcium hypochlorite, and

Half from hydrochloric acid employed either as such or generated from the calcium chloride through action of another strong acid.

In keeping and storing chloride of lime, the factors to guard against are carbonic acid, moisture, light and heat. Therefore it should be kept in closed vessels, and in a dry, cool place.

The total amount of available chlorine has been found to be diminished:

In very hot seasons by 1% per month.

In winter by 1-3% per month.

Composition of chloride of lime:

Lunge (Sulphuric Acid and Alkali, Vol. 3, p. 642) gives two typical analyses of commercial chloride of lime which may be of interest as follows:

Available Chlorine	37.00%	38.30%
Chlorine as Chlorides	0.35	0.59
Chlorine as Chlorates	0.25	0.08
Lime	44.49	43.34
Iron Oxide	0.05	0.04
Magnesia	0.40	0.31
Alumina	0.43	0.41
Carbon dioxide	0.18	0.31
Silica, etc	0.40	0.30
Water and loss	16.45	16.33
	100.00	100.00

From this we might assume the constitution of commercial bleach to be

$$4CaOCl_2,\ 2Ca(OH)_2,\ 5H_2O$$

analyzing

45.1 %	Lime (CaO)
16.85	Water (H_2O)
38.05	Chlorine (Cl)
100.00	

or

68.0%	Calcium Hypochlorite ($CaOCl_2$)
20.0	Calcium Hydroxide ($Ca(OH)_2$)
12.0	Water (H_2O)
100.00	

How to dissolve chloride of lime:

It has already been stated that calcium hypochlorite ($CaOCl_2$) is the active bleaching and sterilizing constitutent of chloride of lime, splitting up in the presence of organic substances into nascent or active oxygen and calcium chloride ($CaCl_2$). The carbonic acid dissolved in the water releases free hypochlorous acid (HOCl) which acts similarly as a powerful oxidizer as well as a specific poison for many pathogenic bacteria. The excess of calcium hydroxide of lime which is present is not so readily soluble, and to this is largely attributable the sludge or milky solution produced.

The point of particular interest in obtaining clear solutions of chloride of lime for a constant feed in water or sewage purification, as well as in bleaching, is that the available chlorine or hypochlorite is quite easily soluble, even in fairly cold water, and the undissolved sludge of hydrated lime, silica, etc., settles readily. At least, settling takes place readily if a few simple rules are observed:

First, do not mix too stiff a paste, otherwise a gelatinizing action takes place and greater difficulty in settling is encountered. Never mix a paste with less than one-half gallon of water for one pound of chloride of lime.

Second, it is not necessary or desirable to grind or break up the lumps too thoroughly; the available chlorine nearly all dis-

solves readily and too much agitation is detrimental to prompt settling.

With these points in mind, we can now consider the preparation of a stock solution of chloride of lime containing approximately 2% of available chlorine.

Three hundred pounds of commercial chloride of lime (35% available chlorine) equals 105 lbs. of available chlorine, assuming a recovery of 100 lbs. of this free from sludge. These 100 lbs. must be contained in 600 gallons to give a clear 2% standard solution. Due allowance must be made for proper washing of the sludge, it thus contains in addition to the suspended lime and silica, a solution of equal strength to that of the clear liquid. The amount of sludge is equivalent to about 1 gallon for each 5 lbs. of chloride of lime used.

Economical working makes it desirable to use two tanks, each equipped with agitators and preferably a looped chain as a drag along the bottom. These tanks should be made of concrete, or at least lined with cement, and adjustable means provided for drawing off the clear liquor from above, as well as an outlet for removing the sludge at the bottom.

Assuming that two 700-gallon tanks are provided, and that 300 lbs. of chloride of lime giving 600 gallons of clear 2% solution are to be prepared in each tank at one mixing, the procedure should be as follows:

Into tank No. 1, which is empty, is drawn 200 gallons of weak wash water from tank No. 2.

Then 300 lbs. of chloride of lime is dumped into the tank and mixed for one-half hour.

The tank is now filled to a mark indicating 660 gallons with the remaining wash water from tank No. 2, which does not have to be particularly clear.

This is now allowed to settle for at least 8 hours and preferably over night. There is ready to draw off to the stock tank 600 gallons of clear solution. There will remain about 60 gallons of sludge which requires washing to obtain the remaining available chlorine.

The agitator is now started and the tank filled to the 660-gallon mark with water, and then allowed to settle.

This wash water is used in making up the next batch in No. 2 tank; the now practically exhausted lime sludge is thrown away.

The standard stock solution thus prepared will contain available chlorine equal to ½ lb. of chloride of lime per gallon, or about 2% available chlorine or 6% of chloride of lime by weight. Hence an average filtered water requiring 8 lbs. of chloride of lime per million gallons will require 16 gallons of this standard solution per million gallons of water. This is a trifle less than 1 drop of this solution containing 2% of available chlorine in a gallon of water.

The following table covers the range of chloride of lime ordinarily used in water purification, and may be found useful for comparison:

Lbs. Chloride of Lime per 1,000,000 gal. water.	Parts Chloride of Lime per 1,000,000 parts water.	Parts Chlorine per 1,000,000 parts water.	Grains Chloride of Lime per gallon of water.	Grains Available Chlorine per gallon of water.	Drops Chloride of Lime Sol. 2% Cl. or 1/2 lb. Chloride Lime (per gal.) used per gal. water.
2	.24	.08	.104	.005	.25
4	.48	.16	.028	.009	.50
6	.72	.24	.042	.014	.75
8	.96	.32	.056	.019	1.00
10	1.20	.40	.070	.023	1.25
12	1.44	.48	.084	.028	1.50
14	1.68	.56	.098	.033	1.75
16	1.92	.64	.112	.037	2.00
18	2.16	.72	.126	.042	2.25
20	2.40	.80	.140	.047	2.50
22	2.64	.88	.154	.051	2.75
24	2.88	.96	.168	.056	3.00
26	3.12	1.04	.182	.061	3.25
28	3.36	1.12	.196	.065	3.50
30	3.60	1.20	.210	.070	3.75

CHLORIDE OF LIME FOR WATER PURIFICATION.

POSSIBLY nothing appeals more to the æsthetic taste than the thought of cool, sparkling water, fresh from some mountain or hillside spring.

Nothing is more vital to the health, the vigor, the productiveness of a community than pure water, and nothing is more readily within our reach if we will but insist upon it.

The ancient Romans recognized this when they built the viaducts to the far-off hills and mountains for their water supply. We do the same in many cases today, and yet with an ever-increasing population the problems of obtaining an adequate and unpolluted water supply is becoming daily more difficult.

Water we have, and plenty of it, but what do we do to preserve and protect it? Our streams and lakes are converted into sewers and catch basins, and then we ask our neighbors down the stream to drink this God-given water which we have poisoned with a myriad germs of typhoid and other intestinal diseases or worse.

This speaks but ill for our much vaunted civilization, and yet this very civilization has given us the means of correcting this evil; furthermore, the fact that we live in cities makes possible a unity of action and scientific control of our water supply which is difficult if not impossible in rural communities.

It is not too much to say that today any city with a population of 50,000 can have a better and more wholesome water supply than is possible in any rural community. But woe betide the city that does not take care of its water supply: the consequences are epidemics—wholesale murder—nothing less. *A case of typhoid fever due to a polluted water supply should be as good ground for legal redress and recovery of damages as a broken limb due to a defective sidewalk.*

The direct interdependence between polluted drinking water and the typhoid death rates have earned for the latter the term "Index of Municipal Sanitation." Recent investigations show that the results of water pollution are even more far-reaching than was generally supposed.

Prof. Charles Gilman Hyde of the University of California brings this out admirably.[176] He speaks of the so-called *Hazen Theorem* as follows:

"Messrs. Mills (1893), Reincke (1893), Hazen (1904), Sedgwick (1910), and others have shown that when a pure water supply has replaced an impure one in a community, the general death rate therein is generally reduced in a considerably greater degree than would be accounted for by the reduced prevalence of Typhoid Fever and other recognized typical water-borne diseases. A study of the vital statistics of numerous places where the quality of the public water supply has suddenly been changed from bad to excellent, as for instance, by the construction and proper operation of adequate purification works, has shown that for every person thus saved from death from typhoid fever, approximately three other persons are saved from death from other causes, many of which have probably never been thought to have any direct connection with, or to be especially effected or influenced by the quality of the public water supply. This numerical statement of the reduction in death rate more or less directly due to improved water supplies has recently become known as the *Hazen Theorem,* because Mr. Allen Hazen in 1903–05 was the first to announce in definite terms this interesting and most encouraging phenomenon. Even such unexpected diseases as tuberculosis, pneumonia, bronchitis, and a series of disturbances causing undue mortality among infants seems to be decidedly affected by such changes in the quality of the water supply. From general principles it is to be inferred that the drinking of a polluted and insanitary water supply must surely tend to lower the vital resistance. On the other hand, an improved water supply must mean a real improvement in the general health tone of the community, a real uplift and reinforcement, rather than an impairment of the vital resistance of the consumer of such supplies."

While all the established facts point to the vital necessity for clean and wholesome water supply, what are we doing and what can we do to insure such a supply to every community in the land?

The use of extremely minute quantities of chloride of lime,

has offered a very practical and simple solution of the sanitary troubles of nearly every city water supply. The most astonishing part of all this is that the true import of these facts has only been realized within the last four years.

As a practical process it dates from 1908, when Mr. G. A. Johnson of New York City was called in to remedy some serious trouble in the water purification at the Chicago Stock Yards. The filtered water of Bubbly Creek[132] contains a large amount of sewage and it had been purified by a process of filtration in conjunction with copper sulphate, but it was the complaint of the large stock shippers that animals drinking this filtered water made less gain in weight than when city water was supplied them. Under pressure of a lawsuit brought by the City of Chicago against the Union Stock Yards Company, the contractors for the filter plant were, however, enabled to fulfill their guarantees by Mr. Johnson substituting chloride of lime for the copper sulphate. The treatment raised the quality of the sewage-laden water from the Creek far above that of the Chicago city water, as was shown in its low percentage of cases where B. coli were found.

	B. coli found
Bubbly Creek, treated	0.34% of cases
Chicago City water	12.8% of cases

The hypochlorite was added 7½ hours before filtration; the addition after filtration did not give as satisfactory results. The amount of chloride of lime added was forty-five pounds per 1,000,000 gallons.

Thus a new epoch in the annals of water purification dates from Mr. Johnson's success at Chicago.

Destroying bacteria in water and sewage by chloride of lime had been the subject of active investigations for some twenty years before, but with the information fragmentary and indefinite in character, the process had not gained credence.

Mr. Johnson gave to the problem (made particularly difficult through large variations in percentage of sewage) its definite solution.

The benefits from this simple expedient have been felt all through the land, where in more than one hundred cities it has

been called in as a prompt and powerful ally in fighting typhoid fever. It has shown itself to fit in with every situation and condition of water supply; with waters from springs or from natural reservoirs, as supplied to New York and other cities; with impounded waters; with the polluted waters from the Mississippi, St. Lawrence River, or Missouri, Ohio and many other sources; where typhoid has been allayed in cities, like Omaha, Cincinnati, St. Louis, Minneapolis, Montreal, as well as in cities adjacent to the Great Lakes, as Cleveland, Erie, Chicago, Milwaukee, where contamination by sewage or chance pollution from shipping and annual winter typhoids had been the rule.

It has been coördinated with every existent process of water purification, as plain sedimentation, sedimentation after coagulation, slow sand filtration, mechanical filtration, single and double filtration.

The value of chloride of lime for straightening out difficulties becomes manifest in a situation like the following, depicted in the testimony of Mr. Calvin W. Hendrick, chairman National Association for Prevention of Pollution of Rivers and Waterways, in the hearings given recently before the Senate Committee on the Owen bill, purporting the creation of a Federal Department of Health:

"Cincinnati takes her drinking water from the Ohio river above the city, discharging her sewage into the same river below for others to drink down the river.

"The cities of Newport and Covington, Ky., use the same river for the discharge of their sewage. The Kentucky state line extends to the Ohio side of the river. Cincinnati is therefore discharging her sewage into Kentucky.

"The U. S. Government is further complicating the matter by building a dam below the city in order to secure a 7-foot channel during low water. To construct this dam the Government will likely back the sewage to the point at which the city takes her drinking water, producing a pollution problem involving three cities, two states and the U. S. Government."

No more valuable illustrations in this connection can be drawn than from our cities adjacent to the Great Lakes. The practice of municipalities of emptying sewage into these large natural

water bodies, which also supply their drinking water, may not appear to be wrong in theory, the self-purifying bacterial activities ultimately being overwhelming, but what are the facts?

In Buffalo (November, 1911) B. coli were found in 5cc. samples, from the new intake on seven days, from the old intake on eleven days.[432]

In Toronto the water from Lake Ontario is bad, 5,000 bacteria per cc. are not uncommon, and of these 25% B. coli.[433]

In Erie, Pa., the typhoid outbreak in the spring of 1911, with death rate of *170* for the first four months, had to be allayed by chloride of lime.[434]

Cleveland forestalled a similar catastrophe by installing a hypochlorite plant at Kirtland Street.[135]

In Chicago, which still discharges 30% of its sewage into the lake, the water is only fairly good, and sterilization became advisable at the 68th Street intake.[123]

Milwaukee, emptying its 60,000,000 gallons sewage into the confluence of the three rivers on the west shore of Lake Michigan acted (June, 1910) very promptly by installing bleach within a week.[142] We also mention Minneapolis, where a recent typhoid outbreak was checked almost before it began.[144]

Besides, all supplies from the Great Lakes are open to chance pollution by steamers.

Amount of Chloride of Lime Used for Sterilization of Water.

The exact amounts of chloride of lime required for water from different sources, etc., vary considerably. The average quantity employed in most cases lies between 5 and 12 lbs. per million gallons of water.

New York City sterilizes the Croton water with 16 lbs. per million.

Cleveland, with a supply of 100,000,000 gallons daily from Lake Erie, likewise sterilizes with 16 lbs. per million gallons.

Even larger quantities up to 25 lbs. have been employed. Also much smaller amounts, as in Milwaukee where they use 6 lbs., and in Pittsburg even 3 lbs. in conjunction with slow sand filtration.

For each water, the dose required must be determined on the

basis of bacteriological trials. It is common practice to increase the quantity indicated, by 25 to 50%, especially when the chloride of lime is added to the unfiltered water. This has been found the better way in order to guard against sudden fluctuations in the quality of the untreated water.

Differences of Treatment Between Filtered and Unfiltered Waters.

Water contains, aside from bacteria, organic matters which claim some of the chloride of lime added for oxidation, and thereby detracts from the efficiency of its sterilizing powers. In line with this, it is well known that turbidity reduces the efficiency of the bleach treatment; also that the total organic content of an unfiltered water has been reduced (oxidized) by 10% (in the case of Harrisburg), the products of such oxidation naturally remaining dissolved in the water.

It has therefore become the more frequently accepted practice in plants where water is filtered to add the chloride of lime to the clear filtered water.

In the following we give examples of the use of chloride of lime in a number of American communities, in conjunction with raw and with filtered waters:

Some Cities Where Chloride of Lime is Used with Natural, Otherwise Untreated Water Supply.

New York City has recently installed a sterilization plant at Dunwoodie, to treat the Croton supply of 380,000,000 gallons of water daily. The ratio is stated as 16 lbs. per million gallons.[101]

Jersey City has used this treatment since 1908, for the water from the Boonton reservoir. Ratio, 5 to 8 lbs. per million gallons. (In 455 samples taken during a period of 62 days, only one case with B. coli was found.)[435]

Council Bluffs, Iowa. Introduced chloride of lime in April 9, 1910, to allay a serious outbreak of typhoid. No cases of fever were reported during May.

Brainerd, Minn. Operated the hypochlorite plant since October, 1910. The water supply from the Mississippi is now free from typhoid contamination.

Erie, Pa. Since the installation of chloride of lime treatment on March 15, 1911, using 7 to 10 lbs. per million gallons, bacterial count has gone down from an average of 234 to an average of 6.6 per cubic centimeter.[66]

Montreal. Since 1910 the whole water supply has been sterilized with chloride of lime at a ratio of 5 to 7½ lbs. per million gallons, reducing the typhoid death rate as follows:[146-149]

	Cases		Deaths	
	1909	1910	1909	1910
October	225	68	27	8
November	218	50	19	13
December	106	52	42	29

Milwaukee. The sterilization plant installed as a result of a serious outbreak of typhoid in 1910, uses 6 lbs. of chloride of lime per million gallons.[143]

Cleveland. An installation for sterilizing 100,000,000 gallons of lake water per day has been recently completed. The ratio is 16 lbs. of chloride of lime per million gallons.[137]

Among the cases of applying sterilization to spring water are
Ridgwood, N. J.
Corning, N. Y.

Chloride of lime is used in connection with coagulation and sedimentation, without filtration, at

Omaha, where the results are stated:

Bacterial reduction in coagulated and settled water....93.30%
Bacterial reduction in coagulated and settled water, and bleach treatment................................99.85
Ratio, 7½ lbs. per million gallons.

Nashville, Tenn. The water of the Cumberland River is treated with 14 lbs. per million gallons.

Council Bluffs. The very turbid Missouri River water is treated by chloride of lime (15 lbs. per million gallons) in addition to alum precipitation.[138]

Grand Rapids, Mich. The new purification plant of 20,000,000 gallons capacity provides alum precipitation with chloride of lime treatment.[140]

Some Cities Where Chloride of Lime is Used in Connection with Filtration Plants.

Little Falls, N. J. Uses chloride of lime with after-filtration.

Harrisburg, Pa. Uses chloride of lime combined with alum coagulation before filtration. The high bacterial efficiency of 99.94% is reported. Ratio 9 lbs. per million gallons.[436]

Baltimore County Water Works Company. Here chloride of lime is added before filtration. It has been found to lessen cost of operation by reducing the quantity of alum used and to lengthen the filter runs. The water is practically sterile. Ratio 12½ lbs. per million gallons.[81]

Cincinnati, Ohio. Thanks to this treatment, ranked most favorably in typhoid rate (5.7), in 1910, among larger American cities. The ratio of chloride of lime used is 5–12½ lbs. per million gallons.[437]

Toronto, Ontario. The new sand filters, put into service January 4, 1912, showed[440] during April:

Bacteria in raw water	18,524
Bacteria in filtered water	815
After sterilizing	5.3

(6 lbs. of chloride of lime used per million gallons.)

Niagara Falls. Two new water purification plants have been put into operation since the beginning of 1912, respectively, by the municipality and by the Western New York Water Company, using coagulation with rapid sand filtration, and following disinfection.

Typhoid Cases.

January	28
February	12
March	5
May	7
June	1
July	1

Minneapolis. The new plant under construction provides

for sterilization with chloride of lime after mechanical filtration of the Mississippi River water.[144]

Pittsburgh. Chloride of lime is used in connection with slow sand filtration. Mr. Johnson states that an increase in efficiency has followed its use. Usually not more than 3 lbs. per million gallons has been required.[84, 85, 86]

Rahway, N. J. Uses it in combination with pressure filters. A recent epidemic of typhoid was promptly cut short by its introduction. The ratio of 25 lbs. per million gallons was used, and not at any time detected by the consumer.

Hackensack Water Company, which supplies water to about 25 communities, uses chloride of lime.[138]

Ottumwa, Ia. The new plant recently put into operation uses coagulation in conjunction with rapid sand filtration, followed by sterilization.[152]

From the foregoing it will be seen that wherever municipal water supplies are naturally very clear or become so by compounding and sedimentation they can be made perfect drinking waters by the use of chloride of lime, and that in cases of turbid waters this valuable agent fits in with every established purification device.

To quote Professor Winslow's statement (1910), "the process adds a great third to the two recognized present methods of water purification, namely, filtration and storage."

It also must be concluded that most small communities not provided with filtration or storage will have no choice but to adopt this most valuable sterilizing agent, even with somewhat turbid waters.

Taste and Odor.

Frequent trials have been made to define the maximum limit for chloride of lime in drinking waters. Speaking in general, amounts not exceeding 25 lbs. per million gallons could not be detected by the senses. This was found in trials with Lake Ontario water at Toronto, where many of the "positive" results were observed to rest on auto-suggestion, belonging to "blanks" inserted in the trials.[89, 90]

Complaints were received at Toronto Island early in 1911

when the rate was 5 lbs. per million gallons, and entirely ceased later in the season when the rate was increased by 150%.

At Rahway, N. J., 25 lbs. per million was not in any case noticed by the consumer.

No reliable evidence has ever been produced that this sterilization has any but the most beneficial influence on health; statements to the contrary must be treated as myths.

Professor Heulett testified in the Jersey City case[91] that in his opinion if 10 lbs. of chloride of lime was added to one million gallons of Boonton water, any trace of free chlorine getting into the treated water would be equal to what has been calculated to become a medicinal dose if a person would drink one gallon per day for 7,180 years.

Any doubts that could linger in the layman's mind, may be dispelled by stating that the U. S. Dispensatory recommends the use of from one to two ounces of chloride of lime for treating 65 gallons of drinking water on board ships. This amounts to fully 200 times in excess of the usual amounts now employed in municipal water sterilization.

That so many cities have benefited by water sterilization, is to be credited to the perfection and certainty to which the process was developed at Bubbly Creek. In addition, a most thorough verification of all the chemical facts involved has marked the first year of the working at the Jersey City Water Works Company at Boonton, where Mr. Johnson coöperated with Dr. Leal in establishing the first sterilized water supply for an entire city, installed in consequence of a lawsuit over the quality of the impounded water from the Rockaway River. The decree of the court says, "I do therefore find and report that this device is capable of rendering the water delivered to Jersey City, pure and wholesome and is effective in removing from the water those dangerous germs which were deemed by the decree, to possibly exist therein at certain times. Upon proofs before me, I also find that the solution described leaves no deleterious substances in the water."[177]

For an exhaustive statement of the chemistry involved, the following passage[178] from one of numerous papers by Dr. Leal could not be surpassed:

"Although the process is not by any means an entirely new one, yet it can be justly claimed that during our investigations and experiments in connection with the subject, much has been learned that was not before thoroughly understood and many facts have been proved which previously had been only theories. The most important of these are as follows:

"(1) That bleach on being added to water ceases to bleach and therefore that criticisms which had been hitherto applied to such addition were without foundation.

"(2) That on the addition of bleach to water the loosely formed combination forming the bleach splits up into chloride of calcium and hypochlorite of calcium. The chloride of calcium being inert, the hypochlorite acted upon by the carbonic acid in the water either free or half bound, splits up into carbonate of calcium and hypochlorous acid. The hypochlorous acid in the presence of oxidizable matter gives off its oxygen; hydrochloric acid being left. The hydrochloric acid then drives off the weaker carbonic acid and unites with the calcium forming chloride of calcium.

"(3) That the process was wholly an oxidizing one, the work being done entirely by the oxygen set free from the hypochlorous acids in the presence of the oxidizable matter.

"We have used during our investigations, the term 'potential oxygen' as expressing its factor of power. When set free, it is really nascent of atomic oxygen and is, in its most active state, entirely different from the oxygen normally in the water.

"(4) That no free hypochlorite or hypochlorous acid would be left in the treated water in the presence of oxidizable matter. It is true that at times in the treated water at Jersey City, we have been able to get the reaction for so-called available chlorine, according to the method of Wagner, as modified by Schultz, there being always oxidizable matter present in such water, and it has been a matter of a good deal of discussion as to the true explanation of this. In my opinion, however, the matter has been definitely settled by the experiments and findings of Prof. Franklin C. Robinson of Bowdoin College, who first found such reaction in untreated Boonton Reservoir waters. It is but natural then, to conclude that this test for so-called available

chlorine is simply a test for an oxidizing agent present in the water, be that what it may.

"(5) That any of the atomic oxygen left after the first action, by which the more easily oxidizable substances are destroyed, unites with those not so easily oxidizable and more slowly accomplishes the same results.

"(6) That no free chlorine could possibly exist in the treated water, the existence of free chlorine being impossible in an alkaline solution.

"(7) That there could be no material change in the quantity of water after treatment, such as would in any way interfere with its use for potable and manufacturing purposes.

"(8) That it could in no way injuriously affect piping, fixtures, etc.

"The atomic oxygen set free from the hypochlorous acid seems to have a selective action upon the intestinal bacteria, as has been established by a long series of experiments by different observers."

From the foregoing and further facts, the nature and limitations of this process become clear. *"Free chlorine" never is present.*

Chloride of lime used in such small quantities will kill bacteria but will not purify organic matter, nor cure discoloration, turbidity or moory and tarry smells in raw waters. The infinitesimal quantities employed for this are far too small; and for the defects mentioned, the other methods, as sedimentary coagulation and filtration are employed in conjunction with chloride of lime.

Of the remarkable germkilling powers of chloride of lime, the statement that for water sterilization *the ratio is one to one million may convey a picture less real than that three grains of a practically harmless substance, will kill the myriads of germs contained in a barrel of water.* To do the same work with the poisonous corrosive sublimate would require at least one ounce, or of the equally poisonous carbolic acid, five pounds!

We show in the following tables two other aspects of the action of chloride of lime when strongly handicapped by presence of organic matter.

1. *Disinfection of screened Sewage, ratio 1 : 25,000, from Experiments by the City of Philadelphia during 1910 (based on 112 samples).*

Sewage Used in the Experiments.	Available Chlorine Added.	Residual Chlorine in Effluent	Total Number of Bacteria per cc. on Gelatine at 20 degrees C. in 48 hours.			B. c li per cc. as per Jackson's presumptive Test.		
			Initial.	Final.	Per cent. Removed.	Initial.	Final.	Per cent. Removed.
Fine mesh screen approximately 1:25,000 (300 parts Bleach per 1,000,000 gals.)	12.4	4.7	2,470,000	337	99.99	121,000	20	99.98

2. *Carbolic Acid and Chloride of Lime compared in pure Typhoid Broth Cultures.*

By Professor Delépine of Manchester University.[41]

	Thread Method.				*Immersion Method.*			
	Test microbe=Bacillus typhosus. Temp. 17° C. Time Exposure 20 mins.				Test microbe=Bacillus typhosus. Temp. 17° C. Time Exposure 10 mins.			
	Minimal lethal dilution, per 100,000		Maximal non-lethal dilution, per 100,000		Minimal lethal dilution, per 100,000		Maximal non-lethal dilution, per 100,000	
Phenol	1/70	1,428	1/80	1,250	1/80	1,250	1/90	1,111
Bleach 32% Cl.	1/1660	62	1/2000	50	1/2000	50	1/3200	31

While in water, containing no considerable amounts of organic bodies, the ratio is 1:1,000,000 in sewage, some of the oxidizing effect of bleach is neutralized by acting on albuminous, peptonic, and other bodies. But even then in the dilution *1:25,000* a *99.99% bacterial reduction* is secured.

The second table refers to research where the necessary amount of organic matter as broth in which the typhoid culture has to be introduced, still more disfavors bleach, yet in the ratio 1:1660 it is shown to do the same work as carbolic acid (not affected by organic bodies) does in the ratio of 1:70.

As the water-borne diseases, typhoid, cholera, and probably diarrhœa, are caused by vegetative, non-spore forming bacteria, no stress is laid in water analysis on any spore forming germs present. A very important feature in water sterilization consists in the selective action of hypochlorite, on the vegetative, pathogenic bacteria, while spore forming ones, that may be present are not readily attacked. Filters exert no particular selection on the bacteria; they remove, and through the best of them sewage bacteria are sometimes found to pass.

Our knowledge on the B. typhosus and the spirillum of cholera is relatively abundant, and few deny that diarrhœa is water-borne.

As to streptococci and tubercle bacilli we are not so well informed, but it is known that they are non-spore forming.

Bacteriology, by showing the true causes of infectious diseases, has indicated us also the means for systematic daily control of water purification work in all its phases. Yet all this work is of very recent date.

Today it seems strange when Professor Frankland[52] informs us that as late as 1892, on a communication received from Robert Koch, he tested water from the London sand filters and found 1,350 bacteria per cubic centimeter, that a heavy fall in "waterworks shares," (The London Water Supply Company) and a clamor for ground-water supply followed publication of his findings!

With chloride of lime as a powerful means for checking irregularities, systematic bacterial control has now extended to the policing of catchment basins. New York City has divided its watershed into a number of districts, each under an inspector with assistants, who send in daily reports and samples of water, and upon the least appearance of B. coli, the dosing with chloride of lime is increased. Such precautionary control has now become more general.

The use of chloride of lime has permitted, at the same time, a simplification and cheapening in coagulation and filtration methods, whenever the latter were employed.

The capacity of mechanical filters was hitherto limited by the requirements of bacterial purification; but now the bacterial

removing function of filters has become inessential; the same applies to slow sand filters, where longer runs have become possible by the use of chloride of lime.

In some cases, for instance in Pittsburgh,[83, 84, 85] the use of bleach has increased considerably the daily capacity of the filter system. The filter beds, after scraping, may be started more quickly, and deeper penetration is bound to follow.

In coagulation methods, where alum, sulphate, lime, soda, are employed, smaller quantities of these chemicals can ordinarily be used if the chloride of lime treatment is resorted to. In the abstracts we refer to the work conducted in 1910 at the Lawrence Experiment Station of the Massachusetts State Board of Health.[82]

For instance, the cost of coagulants, alum and soda for purifying 1,000,000 gallons of the raw water from the Merrimac River is given:

Without bleach	$4.86
With bleach	2.62

A further saving of the general operating expense and labor is noticeable by lessening washing, scraping, handling mud, etc.

Chloride of lime treatment of water supplies is essentially simple; yet it requires able professional supervision. Several cases can be pointed out, where much disappointment was the result of haphazard work, carried out, or supervised, by incompetent persons.

In practice, the performance of this highly responsible work is usually placed directly under supervision of a man competent in bacteriological and chemical problems. Though expert supervision be not required all the time, there are daily bacterial tests to be made, the chloride of lime solutions to be analyzed at regular intervals several times daily, and records to be kept. It is especially important to watch the fluctuations in the flow and character of the water and to change the doses accordingly.

Overdosing or irregular dosing will quickly be noticed by the consumer on account of peculiar though harmless taste and smell of the water.

The design and specifications for a chloride of lime or hypo-

chlorite water purifying plant, should be placed in the hands of competent specialists.

It is out of the scope of this work to enter into all the engineering details which vary considerably with different localities. We must limit ourselves to general suggestions which show the general trend of accepted practice.

A considerable number of installations made in several localities have been described in detail in various publications, more particularly in the *Engineering News*, the *Engineering Record* and the *Municipal Journal.*

To insure the regularity of "Dosing" nothing is required but that the *perfectly uniform* ($\frac{1}{2}\%$) solution of bleach should run from a small feeding tank, always kept filled to the same level, into the water below, which must likewise be maintained at a uniform level, and constructed so that the feeding pipe cannot be clogged up. With no changes in the distances between the two levels, or in pressure, or in size of aperture in the feeding pipe, there is no difficulty in obtaining a uniform flow of the bleach-solution.

For keeping up the level in the feeding tank a ball cock float arrangement is being used; more frequently an excess of bleach solution is charged into the small feeding tank and diverted back to the store tank by an overflow pipe.

At Boonton, Jersey City, the overflow type of orifice tank is used.

To provide for emergencies, there are two concrete orifice tanks 3.5 feet square in plan and 2.5 feet deep. Each tank possesses an adjustable discharge orifice made of a special composition of copper, lead and tin. By means of a fine micrometer screw, a cover is moved backwards and forwards over a slot permitting the use of an area of opening found to give the desired volume of solution under a constant head.

On leaving the orifice the solution flows by gravity through a 3-inch galvanized iron pipe line to the screen chamber located beneath the main floor of the gatehouse. There the main line branches into four lines of 1.5-inch galvanized pipe, each extending to a grid fastened over the face of each of the 48-inch mains coming from the reservoir. The grids are made up of 1-inch pipe drilled with twelve $\frac{1}{4}$-inch holes pointing downward.

In case of any stoppage in pipes or the breaking down of a pump, an alarm bell attachment operated by means of a float signals the attendant. Special bronze pumps have given satisfaction, and black iron pipes have lasted for over two years.

For large installations, the use of a "venturi" tube to regulate the supply of chloride of lime solution of known strength, in exact proportion to the flow of water, has proved very satisfactory.

In Omaha the plant was installed under direction of Dr. Leal, of Paterson, N. J., whose merits in water sterilization in connection with establishing this work in Jersey City have been mentioned. The same feeding tank system is in use; and as some trouble has been experienced with the clogging up of orifices, additional readings on the store tanks for the bleach solution are taken each hour and recorded on printed forms.

In preparing the bleach solution, all lumps are first broken by stirring paddles, converting the bleach with little water into a thick paste, which after two hours stirring is then somewhat diluted and run for final solution into two storage tanks of reinforced concrete on the floor below. These storage tanks of 4,100 gallons contents will supply a 32-hours run each; for the 17,000,000 gallons daily water consumption. Continuous stirring in the storage tanks, while in use, is now the rule.

In Omaha, the Missouri River water is treated by sedimentation and subsequent sterilization.

Minneapolis provides sterilization as an integral element of its modern water purification plant now under construction. The water comes from the Mississippi River, and the process includes alum coagulation and mechanical filtration. Mr. Rudolph Hering, of New York City, has introduced some valuable new devices, as for instance, a scheme for removing the hypochlorite from the drums entirely under water.

All of the apparatus for applying the chemical solutions, including pumps, piping and feed tanks, are in duplicate. The feed tanks are of the overflow type; the piping for the hypochlorite is of lead, two inches in diameter; the bleach solution is introduced at the clear water reservoir.

The installation at Montreal has a ball cock float regulator.

A feeding tank, which may be raised or lowered by means of a small crank so as to raise the head was made under direction of Mr. J. O. Meadows, sanitary engineer of the Provincial Board of Health.

Other devices for keeping constant levels for feeding are more applicable to smaller cities.

At Brainard, Ind., the storage tank for the clear bleach solution consists of an hermetically closed barrel, with an ever open outlet pipe into the small feed, or orifice tank. Another pipe, from the air space at the top of the closed storage barrel, leads to the top space in the open feed tank below; this pipe becomes sealed up with the liquor in the feeding tank, rising to it, and as no air can get into the storage barrel, its discharge into the feed barrel is temporarily stopped.

In such a manner, feed regulation is successfully managed at Strathcona, Alberta (population 5,000), with the "portable" sterilization emergency plants, constructed by the Minnesota State Board of Health for prompt shipment to any communities in trouble.

Other states have followed this example, as the Kansas State Board of Health.

Quick and effective mixing is obtained in different manners by baffling or stirring devices. Though the germicide action of the hypochlorite is very rapid, a minimum contact of one hour is generally allowed, and considered more than ample, before the treated water reaches the consumer at the tap.[177]

Swimming Pools and Public Bath Houses.

An "intermittent sterilization" of the water used in *public bath houses and swimming pools* has come into favor during the past two years.[113-120]

In most cases the pools are being dosed daily in the proportion of one pound to one and a half pounds bleach per 100,000 gallons; the treated water can be used several days longer without draining and cleaning the tank, and a saving (in one case stated at $9.70 per week), naturally ensues.[116]

Accumulating data have forced the sanitarian to look upon

swimming pools as very dangerous centers of infection; and the swimming pool has been suspected of causing eye, and even syphilitic, infection, as well as the grippe, sore throats, pneumonia, diarrhœa.[113,116]

Aëration and filtration alone of the water in swimming pools cannot sufficiently remedy infectious conditions. The results achieved by chloride of lime in a number of universities and colleges, as Brown University, Brooklyn Polytechnic, Northwestern University, the Carnegie Pool at Yale, Purdue University, are very gratifying.

At Purdue the bleach was thrown over the surface of the water at the rate of 20 lbs. per 1,000,000 gallons; at Brown University 12 lbs.; at Yale 8 to 12 lbs. are used pro rata.[118] At the University of California[120] 15 lbs. of chloride of lime *are applied once a week.*

Other Methods of Water Sterilization.

While we are on this subject, mention ought to be made of other methods of water sterilization, which have been tried with varying success, for instance, methods based on the use of copper sulfate, of ultra violet rays, ozone, free chlorine, etc.

Copper Sulphate, though discarded as a sterilizer, is still used for destroying the green algæ, diatoms and other microörganic growths which cause clogging of water filters (in a ratio of about .20 per million).

Sterilization by bleach has greatly lessened these filtration difficulties, and through destruction of algæ growths the periods between necessary scraping of the sand surface have become lengthened.

Ultra-violet rays. Their most powerful germ-killing effects are entirely marred by the fact that these rays *will not permeate water unless it be absolutely clear.* In presence of the slightest haziness, or certain bodies which may be dissolved in perfectly clear liquids, the ultra-violet rays will not penetrate beyond the fraction of a millimeter; into such solutions as absolutely clear wine or beer they cannot enter. Furthermore, the factor of cost also is prohibitory.[165,166,183]

Ozone, which would be for many reasons an ideal agent,

seems also debarred from extended used by its excessive cost. Large trials with ozone were first made in 1898 by the well-known firm of Siemens and Halske, Martinikenfelde, near Berlin.[183]

As an outcome two cities in Germany adopted ozone, Shierstein (since discarded) and (1902) Paderbern, a small provincial town in Westphalia.[183]

There has been relatively little development on a working basis since; in France several installations have been made, and one in Russia, for part of the water supply of a district in St. Petersburg, with a daily consumption of 13,200,000 gallons.[158, 160, 161]

For this plant, the operation costs alone, including cost of aluminum sulphate and rapid filtration, is given at from $15 to $17 per 1,000,000 gallons.

With a French installation under construction, it is thought that the working cost will be brought down to $14 per 1,000,000 gallons.

Cost of ozonizers is given as $15,000 per 2,500,000 gallons water, without housing.

The large outlay and high working cost for ozone sterilization may seem less formidable in Europe with a daily water consumption so incomparably out of proportion to our own, where for example, the consumption is

	Per Capita
Paris	37 Gal.
London	45 Gal.
Vienna	26 Gal.

which, as against the following American cities, would be ruinous:

Chicago	232 Gal.
Detroit	167 Gal.
New York	100 Gal.

The operating cost of $15 to $17 per million gallons at St. Petersburg can but be contrasted with that of a city where chloride of lime is used. Take, for instance, the total operation cost in Cincinnati (1910), reported[437] as follows:

	Cost per million Gal.
Sulphate of alumina	$1.75
Bleaching powder	.08
Analysis of water	.29
Labor	.59
Inspecting water shed	.11
Miscellaneous	.05
Cleaning reservoir	.25
	$3.12

In other cities, we note similar results:

St. Louis (1910)	$4.75
Richmond, Va. (1910)	5.27
Albany (1910)	5.99

The chloride of lime sterilization plant of the Montreal Water Works Company, for 12,000,000 gallons daily, has cost $1,182.

At Omaha, for 17,000,000 gallons daily, the cost of the plant, including buildings, was $3,750.

Running expenses at the Montreal Water Works Company were, per million gallons

Chloride of lime	$0.10
Heat and light	.015

At Kansas City, 30,000,000 gallons are sterilized daily at the cost of 27¢ per million gallons. The ratio of chloride of lime used is 5–7½ lbs. per million gallons.[439]

Liquid chlorine has been tried experimentally for the purification of water by first preparing a solution of chlorine water and adding this chlorine water for sterilizing purposes. Under extreme dilutions this chlorine water seems to have much the same efficiency in its toxic action on bacteria. The chloride of lime, however, forms the most economical means for preparing and transporting available chlorine or oxygen; and also the solution so produced can be made much more concentrated, and much more readily standardized. Unit for unit, the chlorine in chloride of lime can be made available for perhaps ⅛ of the cost.[137 439]

Recently the use of liquefied chlorine for the purification of

water has been taken up by Dr. C. R. Darnall. (See *Journal of the American Public Health Association*, Vol. I, No. 11, November, 1911, "The Purification of Water by Anhydrous Chlorine.")

The method and apparatus are covered by patents.

It is claimed that the use of chlorine is just as efficacious as that of hypochlorites, or chloride of lime, as well as ozone, and that it is considerably cheaper than ozone. It is claimed also that it is easier to use than chloride of lime, because it can be mixed and dosed more readily. It is further claimed that it does not so soon impart an objectionable taste to water as chloride of lime.

There is no doubt that chlorine can be used very efficaciously, for sterilization. It should be noted, however, that there is no difficulty whatever in mixing efficiently and in properly dosing the amount of chloride of lime to be used in conjunction with water which has to be purified.

Chloride of lime as furnished by competent manufacturers varies very little in strength, and if there are any variations, they are so small as to amount only, at the utmost, to about 10%. Furthermore, nothing is easier than to determine promptly the strength of a chloride of lime solution. With a simple laboratory apparatus, the operation can be carried out within one or two minutes. The trouble connected with properly dissolving chloride of lime, and determining its strength, is certainly no greater than the precautions which are required to handle highly dangerous and corrosive chlorine gas. Whoever is able to operate under one method, will certainly have no more trouble in using the other.

It should be stated that chlorine gas, used in excess, will impart just as readily, and probably more easily, a special odor and taste to the water. But there is no reason why in either method any excess should be used, when it is so simple to avoid overdosing.

In regard to this, it should be noted that the objectionable taste or odor is caused by chlorine substitution formed from organic substances contained in water. As stated before, chloride of lime does not act here by its chlorine, but by its oxygen derived from the hypochlorous acid which is set free by the action

of the carbonic gas, present in the water, on the hypochlorite. Therefore, chloride of lime is less liable to form chlorine substitution products than if free chlorine is used.

It should be borne in mind that just at the point where the chlorine is introduced in the water, a considerable excess of free chlorine will exist for a few seconds until it has been distributed in a larger volume of water. Just during that short time, when this excess of chlorine is present, the possibility of the formation of chlorine substitution products is self-evident, in case the water contains organic bodies.

Whoever has practical experience with the use of chlorine or has knowledge of organic chemistry, knows how easily chlorine substitution products are formed, whenever chlorine is brought in contact with organic bodies.

The substitution products formed by the action of chlorine on organic matters derived from plant life, have a very penetrating and characteristic smell, which can be noticed by taste and odor long before chemical analysis could detect them.

There is no reason why water treated with chloride of lime should have any taste or smell whatever, unless the operation is performed carelessly or unless an unnecessarily large amount of chloride of lime is used.

Under the circumstances, everything resolves itself to the careful application of one or the other methods. Without some care, both methods may lead to objectionable results.

It is quite possible that there may be instances where the use of liquid chlorine may have its advantages over that of chloride of lime, but even then, the cost of the liquid chlorine process will be considerably higher. Not only is liquefied chlorine more expensive than chloride of lime, but to the cost per pound, must be added the not inconsiderable item of cost or rental of expensive steel containers. Furthermore, the freight and handling of these steel cylinders, with liquefied gas, involves extra transportation risks. They are classed as dangerous freight, with the attending restrictions.[137]

SEWAGE DISINFECTION.

IN A recent report by the Metropolitan Sewage Commission of the City of New York Dr. Soper, the president, informs us that the daily flow of the 600,000,000 gallons of sewage of that city, would fill the Flatiron Building every 46 minutes, and if the suspended matters were concentrated into a thick sludge, a volume equal to that of the Flatiron Building would have to be discharged twice a week into New York Bay.

In dry substance this sludge is reported to consist of (annually in tons):

Feces	77,600
Toilet papers and newspapers	44,300
Soap and washings	60,900
Street wastes	44,300
Miscellaneous	22,200

What becomes of this stupendous volume of filth? By what benevolent agency have we been enabled to pour this stream with its tons of putrescent matter day after day and year after year, into New York Bay, and withal find that in very existence disappears from our sight? New York Harbor is as clean today as it was twenty years ago. Why?

As a matter of fact, a satisfactory answer, as to what becomes of the enormous quantities of human waste, is now at hand, though strange to say, it could not have been furnished as recently as five or ten years ago.

Liebig, who dominated chemical thought during the middle of last century, described and ridiculed Pasteur's great discovery of anaërobic fermentation. Yet the remarkable efficiency of destroying organic matter by anaërobic action was the underlying principle of the first sewage-disposal contrivance based on bacterial action.

This invention of Mouras, a Frenchman, whose American patent of November 28, 1882 (U. S. Pat. No. 268120), although preceded by 20 years' practical use for an "Automatic Scavenger," permits sewage, kitchen waste and the like to be made

to liquefy in an air-tight, hermetically sealed tank. This tank is completely filled with water before being placed in service, and after having been properly set working, when anything is discharged into the feed pipe. an equal volume of liquid is expelled from the outlet and of the "Scavenger," then this liquid only contains disintegrated and decomposed material because resistant substances like paper, etc., disappear in a short time.

The study of sewage disposal by means of bacterial processes, during a period of 25 years has brought to light much valuable knowledge of what takes place in our water courses, estuaries and inland lakes, wherein sewage is discharged and is being digested. Furthermore, with the strides made in the knowledge of aquatic life, it became recognized as a very important factor, that many sewage matters serve as direct food for the grosser vegetable and animal microörganisms, collectively called "Plankton" (from the Greek "wandering"), and that disposal of sewage into water courses delivers it to a cycle of life activities developing from the very lowest organisms until it finally terminates in healthy fish life. Sewage disposal thus became also a botanical and zoölogical problem.

We now invite the reader to a brief discussion of the important differences between sterilized and unsterilized sewage, differences of paramount importance as regards maintenance of the oxygen balance in waters into which such sewage becomes discharged.

The bacteria originally contained in crude sewage, (1 to 4 or more millions per cubic centimeter at the outset) make a tremendous onslaught on the dissolved oxygen. All life must breathe. Sewage, at its origin, is well supplied with oxygen. But while the sewage passes through the sewerage pipes, bacterial activities consume much oxygen and at the moment it enters the river, it may have all vanished.

At Columbus, Ohio, as stated in Mr. Johnson's report of 1905, page 36, dissolved oxygen was ordinarily lacking in the outfall sewer at the testing station from about 10 a. m. to about 4 p. m. During the remainder of the day dissolved oxygen was present in varying amounts up to a maximum of about 3 parts per million from about 2 a. m. to 7. a m.

It must seem strange, as Mr. George M. Wisner points out in the Report to the Sanitary District of Chicago,[220] that when the drainage canal was designed, practically nothing was known on the absorption of oxygen from water by organic sludges. The modern conception that the all-important oxygen supply is an important factor in "planktonical" life, marks the trend of present day thought.

When crude sewage is discharged into the river where it becomes diluted, the sewage bacteria engender in the first stretch of the water an intense multiplication. All oxygen present in that zone is consumed suddenly, and putrefaction and foul odors appear, unless a very large body of water with rapid flow is receiving the sewage.

Sterilization by chloride of lime sends to the diluting river water, a sewage free from germs, and supplied with oxygen. Sewage sterilized with chloride of lime, preserving its non-putrescible nature, is made directly acceptable as food to the vegetable and animal microörganisms, the "plankton," as well as to fish life.

The removal of pathogenic or other sewage bacteria could hitherto not be effected entirely by any of the established purification processes. The Report of the State Board of Health, Massachusetts, 1910,[192] recounts the reduction in all sewage bacteria as amounting to:

By settling, to........................	58%
By the Imhoff tank, to..................	46.6%
By a contact filter, to..................	47.20%
By a trickling filter, to................	87.90%

while the report of the experiments on sewage disinfection by chloride of lime, as conducted by the Board of Surveys at Philadelphia shows[230] a removal of 99.99%. Furthermore, while most of the disease germs will finally succumb in large bodies of water, it has been shown by numerous painstaking determinations that some of them, for instance, typhoid bacilli will live in fresh-water, sea-water and in oysters at least from one to four weeks.

Mr. George W. Fuller in his valuable work on Sewage Disposal, 1912, says:[199]

"Fortunately there is now available by the hypochlorite method a reliable means of sterilizing or disinfecting sewage or water at a small cost. The full significance of this is not yet fully appreciated. It has much bearing on the question of sewage disposal in general."

Here, then, is a method by which it is possible to deliver to the diluting river, lake or sea, a sterile sewage freed of pathogenic germs and of germs of putrefaction.

All traces of the sterilizing agent vanish at the point of dilution. Furthermore, the studies by the Board of Surveys of the City of Philadelphia in 1910[231] show that the chloride of lime became exhausted within ½ to 1 hour, where 175 lbs. had been added per million gallons sewage; 2 to 3 hours, where 250 lbs. had been used.

The assimilation of the vast quantities of organic sewage matters, rendered non-pathogenic, is proceeding gradually; in part, through the river bacteria, and largely by the vegetable and animal plankton. And this transformation into healthy food for fish, is accomplished without putrefaction or the formation of gases and other decomposition products, esthetically offensive, and so poisonous to fish life.

Destruction of the pathogenic germs in sewage, or sterilization of sewage by chloride of lime, has received attention from scientists and sanitarians for more than thirty years, but it was made a practical and economical process by Prof. Earle B. Phelps, through his memorable investigations[277] in Boston in 1906, followed by a first installation at Red Bank, N. J. Phelps places sewage-sterilization on such a definite and reliable basis that a number of large and smaller communities are now being benefited by the results of his labors.

Financial aid had been received from the U. S. Geological Survey, from state and city governments; also the Massachusetts Institute of Technology had been interested in the furtherance of his important work.

Nor had this been accomplished too soon by any means. The original idea to guard against danger in time of epidemics, and to protect the water supplies of communities lower down by sterilising sewage before turning it into water courses, had been

born of sad experience, but of late has become appallingly intensified.

Nowadays, sanitarians admit no "exceptional times of epidemics;" they are permanently with us through the typhoid carrier.

On this subject, we have before us an exhaustive treatise by Dr. J. C. G. Ledingham, recently published in the 39th Annual Report of the local Government Board for England and Wales. The number of *typhoid patients who, after reconvalescence, became chronic carriers* is given as respectively *3.8%, 2.2%, 3.1%*; and from 6,708 cases, controlled by one of the South German typhoid stations, as *2.47%*.

But a more startling evidence from *healthy persons,* chosen at random, whose excreta have been examined is furnished; 1,700 persons (living in the neighborhood of actual cases) showed 8.8 carriers per 1,000; 1,014 in Washington, D. C., showed 3 carriers per 1,000, and 250 persons showed 5 carriers per 1,000.

Adapt these figures to New York City, and *we have, respectively 15,000 or 25,000 or 44,000 persons in New York who daily discharge typhoid germs.*

The 558 deaths from typhoid fever that occurred in New York City during 1910 permit a surmise that all the year round about 1,500 typhoid patients would be discharging excreta, more or less disinfected, into the sewage.

But why trouble about the stools from 1,500 patients, if 25,000 shed typhoid secretions anyhow! This is a condition of the utmost gravity. Who would choose to bathe in New York Bay, in case there were 25,000 or 40,000 down with typhoid?

Even recently an epidemic at the Royal Marine Depot, Walmer, England, was caused by the soldiers using a swimming pool, filled by a rising tide, some distance from one of the Walmer sewage outfalls.

Only enormous amounts of typhoid excreta that get into sewage can explain a passage from D. D. Jackson's report to the Merchants' Association of New York, 1909.

"At many points, sewer outfalls have not been carried below the low-water mark, in consequence of which the solid matters from the sewers have been exposed on the shores." These de-

posits were found to be covered with flies, thus affording ample opportunity for the transmission of typhoid. It was furthermore found that the greater number of typhoid cases were found near the waterfront.

Without any possibility of doubt, the number of pathogenic germs in sewage is entirely underrated! We have here to take into due consideration certain natural qualities of the typhoid germ.

Flourishing at body temperature, the typhoid bacillus is at a disadvantage in the cooler river water, to which his enemies are better acclimated; especially where large food supply is given the latter multiply out of proportion. Pure typhoid cultures multiply much more rapidly in distilled water than in lake water, for reasons of this kind, but they also have been known to survive in river courses for 90 miles.

The annual typhoid epidemics of our lake shore cities in winter, when hostile bacterial life is not as prolific as in summer, prove the passing of the typhoid germs from sewage outfalls to intakes of drinking water.

The various steps in sewage *treatments* by ordinary methods, septic treatment and percolating filters, have very little eliminating effect on pathogenic bacteria.

With our eyes suddenly opened about the typhoid carrier, an annoying feeling of distrust in the purity of the beautiful waters near which we pass our summer vacations, on which our pleasure boats ply, and in which we bathe, must impel us promptly to remedy revolting conditions until recently actually unknown even to the professional sanitarian.

True chronic carriers were not known in this country until this extremely important phase of the typhoid question was brought vividly to the attention of the American people under the following circumstances:

Dr. L. O. Howard, Chief of our National Bureau of Entomology, was consulted in the case of "Typhoid Mary," a cook with a family on Long Island, where during the summer of 1906, several cases of typhoid occurred.

Upon his advice, Dr. George A. Soper, of New York, was called in to make a thorough investigation. The results of Dr.

Soper's search were most interesting.[371] After studying every possible source with absolutely negative results, the proper examinations were begun, and it was discovered that Mary, the cook, was a chronic carrier. Her past history was looked into, and it was found that for several years there had been typhoid cases in nearly every family who had engaged her. She was immediately isolated, and kept in custody for three years. Then she was released, promising never again to engage as cook and to report at frequent intervals. She returned after four months saying that she could get no work and was placed by the New York City Department of Health in one of the laundries of a public institution, where she still remains.

Brief reference is in place here to the bearing of sewage pollution on oyster beds, drawing increased attention since the new revelations of typhoid carriers became public.

The extensive shellfish industries in this country are of great financial importance, and compare in that respect favorably with other enterprises concerned in the production of food materials. To millions of people a valuable article of food is furnished and thousands of individuals find profitable employment in developing and carrying out the business in all its phases.

New York City alone consumes $7,000,000 worth of oysters per annum, besides clams, scallops, etc.

On the vitality of typhoid bacilli in sewage polluted water and oysters much scientific investigation has been undertaken. Says Dr. Savage: "It is justifiable to infer that typhoid bacilli can survive in polluted muds for at least two weeks."[48]

Dr. Klein[48] Medical Officer of Health for London, England, says: "It is definitely settled that baccillus typhosus will live in oysters;" also "that an oyster infected with large numbers of typhoid bacilli 'cleans' itself in about from 9 to 12 days when placed in clean water which is frequently changed, further . . . that oysters kept in a dry state, though capable of destroying the bacillus, yet remain polluted for a much longer period than oysters placed in constantly changed clean water."

Steaming contaminated oysters and clams in the shell, or cooking them after shucking for 15 minutes at boiling temperature,

practically destroys all typhoid germs, but as in practice they never are cooked for this length of time, cooking cannot be depended upon to remove this danger.

In Providence, R. I., examinations of the oyster-beds this fall, previous to certification by the State Commission of Shell-Fisheries, showed that many acres of beds that were condemned a year ago can now be certified under the rigid standards of that commission and that the dead line for oysters has moved a long way up the Narragansett Bay, a result due without doubt to the disinfection treatment.[269]

To the layman, one of the most striking features of the sterilizing process with chloride of lime, is the relatively small amount of disinfectant necessary; for average crude sewage an amount equalling 90 to 120 lbs. of chloride of lime per 1,000,000 gallons suffices, which will cost in the neighborhood of $1.20 to $1.60 per million gallons treated.[236, 238]

Phelps states that by the use of that quantity disinfection is accomplished in a very few minutes, and storage periods of not over 15 minutes are ample. This is fully borne out by the Philadelphia results.[232]

With screened crude sewage, 120 lbs. chloride of lime added to 1,000,000 gallons, a bacterial reduction of 99.88% was shown within the first 10 minutes contact. This would greatly reduce the cost of land and tank construction for large disposal works.

On this account, the technical side of the process presents no difficulties.

Into 10,000 gallons of screened sewage four gallons of a 3½% solution of chloride of lime is to be incorporated. Four hundred gallons of a solution in this strength will therefore sterilize 1,000,000 gallons of the screened sewage. The solution tanks of reinforced concrete, fitted with stirring gear, are provided in duplicate, each of a size to supply two 30 hours runs.

Dosing of sewage with the exact amount of this solution is effected through the small orifice feeding tank, with constant liquor level, as described in the chapter on Water Sterilization to which we refer.

To assure proper and uniform distribution of the bleach-solution to the sewage, the admixture takes place in a horizontal

cross-section, the flow of the treated sewage then continuing downward, passing several horizontal baffles, and thus thorough mixing is secured in a vertical plane.

In recent installations, as, for instance, proposed for the joint sewage disposal works for Orange, Montclair and East Orange, N. J., a venturi meter will regulate the flow of the sewage, and as the flow through the meter increases or decreases, the difference in pressure on the two pressure chambers of the meter will regulate the ingress of the chloride of lime solution accordingly.

For completing the sterilization, the treated sewage must then be held for fifteen minutes by passing through a continuous-flow storage tank.

The total cost of the process, including interest charges upon the necessary fixtures, labor, and other items, will range from $1.00 or less in the case of effluents from percolating filters to about $3.00 in the case of crude sewage, per million gallons.[244]

We give in the following table an itemized account of the combined working cost for the three proposed new plants for sewage disposal by *screening,* and *subsequent sterilizing with chloride of lime* at New Brunswick, N. J., treating respectively 900,000, 3,000,000 and 2,500,000 gallons daily flow.

	Per annum.
Superintendent	$1,200
3 attendants	2,160
Team for handling chemicals and screenings	500
Teamster	600
Chemicals	2,500
Coal	1,500
Power for running screens and conveyors	1,500
Average cost of repairs and renewals	750
Total	$10,710

The above statement of cost of operating and maintaining is taken from the estimate of Messrs. Hering and Fuller in 1911. The cost mounts up to $4 per 1,000 gallons, owing to the separate treatment of the 6,400,000 gallons of sewage in three different localities. The total construction costs of these three plants was to be $70,000.

The following table by Professor Phelps refers to the total cost of sterilizing with varying amounts of bleach (chloride of lime):[244]

TOTAL COST OF OPERATING DISINFECTING PLANT.

Based Upon a Plant Having a Capacity of Five Million Gallons per Day.

Bleach.	*Cost per Million Gallons.*					
	Fixed.			*Operating.*		
Pounds per Million Gallons.	Storage Tanks.	Other Fixed Charges.	Bleaching Powder.	Labor.	Power.	Total.
50	$0.05	$0.04	$0.60	$0.10	.....	$0.79
75	0.04	0.05	0.90	0.10	$0.02	1.11
100	0.03	0.07	1.20	0.10	0.02	1.42
125	0.03	0.08	1.50	0.10	0.03	1.74
250	0.02	0.16	3.00	0.15	0.06	3.39
375	0.02	0.24	4.50	0.20	0.09	5.05

For a comparison we give the cost of sewage treatment by three types of the accepted disposal methods, taken from the respective city reports for 1910.

Per 1,000,000 Gallons.

Columbus, Ohio.

Septic treatment and percolating filters, $9.03, including $4.03 for fixed charges.

Worcester, Mass.

Chemical Precipitation, $11.00 including $5.75 for fixed charges.

Worcester, Mass.

Sand Filtration, $17.21, including $8.56 for fixed charges.

Thus the advantages of sewage sterilization comprise:

1. Absolute accuracy against the pollution danger, now ad-

mitted to be many times more grave than could be assumed ere the true facts about the typhoid carrier became known.

2. Assurance that sea bathing and the consumption of oysters can be made quite safe.

3. The simplicity of the process and low cost of construction and working, permitting even small communities to attain the benefits of sewage disposal.

4. The small area required admits of locating the plants in more suitable places.

5. This advantage, combined with the simplicity of process, allows placing the disposal plants separately near to the several outfalls, without diverting the sewage to central disposal works.

6. Greatly reducing the load for self-purification put on the rivers and water courses, and preventing putrefaction.

7. The low cost for installation, both in construction cost and for land required. A city population of 100,000 calls for an area of five acres for an ordinary disposal plant, and its construction cost would amount to four or five times that for sewage sterilization by chloride of lime.

8. Low operating cost; in addition the fixed charges are greatly reduced on account of the much lower cost for construction and land.

Among the cities which have provided for sewage sterilization by chloride of lime is Baltimore, Md., where Mr. Calvin W. Hendrick has designed and constructed complete sewerage of the city with disposal plant. Service for about 275,000 population was finished in February, 1912.[268]

The oyster beds of Chesapeake Bay are about 16 miles distant from percolating filter effluents which will be sterilized with chloride of lime.

Philadelphia. The new plant dealing with 2,000,000 to 4,000,000 gallons daily, begun in October, 1910, was designed upon results from the valuable work at Spring Garden Experimental Station. This plant is a tentative step pending the adoption of sterilization for the whole city's sewage.[266]

Milwaukee. The commission appointed September 2, 1909, has now recommended sewage treatment of clarification by sedimentation with following disinfection.[441]

New Bedford has been advised to adopt sewage sterilization in recent reports by Professor Phelps and Prof. W. T. Sedgwick.[238]

New Brunswick, N. J.,[226] contemplated sterilization under the advice of Messrs. Fuller and Hering of New York City. A number of other seaboard towns, as Red Bank, N. J., Rahway, N. J., Shore Harbor, N. J., Ventnor, N. J., and Atlantic City, N. J., had plants constructed by Professor Phelps; others, as Bridgeton, N. J., Keyport, N. J., and Margate City, N. J., by Mr. Clyde Potts of New York City.

STREET SPRINKLING AND FLUSHING.

FOR the last eight years street dust has been the subject of much study by eminent bacteriologists, and other men of science, with the result that the causative connection between street dust and a number of diseases is now clearly established.[377]

B. tuberculosis, B. coli. comm., the bacterium pneumococcus, staphylococcus and streptococcus, pyogeneus, diphtheria, anthrax, tetanus, have been recognized as permanent inhabitants of dust.[377, 379] Out of forty-six inoculations into animals by Dr. Concornotti, with bacteria from city dust, thirty-two caused infectious diseases.[382]

Tonsilitis, quinsy, laryngitis, pneumonia, influenza, tuberculosis, asthma, rheumatism, diarrhœa, skin disease, conjunctivitis, trauma of the cornea, nasal catarrh or frontal sinus affection, middle ear disease from irritation of eustachian tubes, all these lurk in the dust of the streets.[383]

Again, dust may, by predisposing an irritated condition of the respiratory organs, so lower the vitality of the mucosa that the development of any germ deposited thereon will be favored.[384]

Every autumn, when our children return from the dust-free country, they begin to suffer from all kinds of colds within a week; temporarily unacclimatized to dust infection, their tender respiratory mucosa succumbs to the fresh bacterial onslaught, and conjunctivitis, rhinitis, tonsilopharingitis, often are the result.[384]

Chronic catarrhal colds and augmentation of the adenoid growths frequently are due to irritation and infection by dust.[383]

A new alarming relation between dust and disease stands revealed in the fact that experimental proof has now been brought (Neustaedter and Thro)[385] for dust-carried infection of infantile paralysis.

These investigators conclude, that the nasopharynx is probably the point of entry, and also that acute poliomeylitis is both infectious and contagious.

Suspicion of street dust as the worst etiological mischief maker

now finds frequent expression in the medical press, so for instance by Dr. Hill in the 1910 report of the Minnesota State Board of Health. . . . "It seems not unreasonable to suppose, that the ending of the Winona outbreak when the watering began, was not a mere coincidence, especially since Eau-Claire and New Richmond in Wisconsin had previously had similar experiences."

Dr. Willis H. Hall, Medical Inspector of the Seattle Department of Health, similarly says in his report on the local outbreak in 1910:

"It seems to me that these two districts both together having fifty cases out of the total of eighty-nine, with no congestion of population, show the exact effect of dust in carrying of the contagion, or that the conditions existing which favor the carrying of dust, also favor the transmission of this contagion."

Definite knowledge of *all* the ways in which this dreadful disease is disseminated is still lacking; however, dust and flies are principally adduced as carriers of infection. Meanwhile, it is a fact worthy of note, that the germ readily succumbs to disinfectants.

Tuberculosis. The hardy character of B. tuberculosis is unfortunately too apparent, not only when in *sputum* but *when kept in a dry condition*, where it has been found to keep virulent for 10 months.

Dust ranks foremost as conveyor of tuberculosis from man to man. Admitting all the beneficent results of the anti-spitting ordinances, there exists still gross pollution of city dust from dried sputum, from stumps of cigars, cigarettes, etc.

Infantile Diarrhœa is carried specifically by flies and dust; very rare among breast-fed children, its causation by milk infected from flies or through dust is obvious.

Among an average of 100 children with summer complaints only four have been found to be breast-fed.

In a recent exhaustive report on Infant Mortality (1910) by Dr. Newsholme,[130] the well-known tuberculosis authority and chief of the medical division of the Local Government Board for England and Wales, *flies* and *dust* stand out as two of the gravest causes for infantile mortality.

He cites as reasons: inefficient garbage disposal, faulty disposal of excreta and unpaved or unmade roads, and says:

"The heaviest infant mortality from diarrhœa occurs in the districts in which the three forms of sanitary defects enumerated above are rife, and districts from which these defects are removed experience a lowering of infant mortality which is greater than that in which these evils continue. . . . "

"*Catching cold*" is really a dust infection contracted in places where people congregate, or where much traffic circulates currents of dust! Arctic explorers have reported repeatedly that notwithstanding the extremely low temperature and great exposure, they only "caught cold" when nearing settlements.

Street dust contains ashes, detritus of paving-stones and asphaltum, house-sweepings, excrements of horses and dogs, dried sputa, dead disintegrated insects, pulverized earth, plaster and cement, iron dust, earth from street excavations, soot from chimneys, cigarette and cigar stumps, house dust, debris from fruit stands, garbage, etc., and even human excrements, which in crowded tenement regions are frequently voided by children or adults in dark alleys and ill-lighted streets.

All this filth is being whirled into our faces by the wind, by motor cars, and other vehicles, while we walk or drive; into our homes, where in these times of "fresh air cult" the task of "dusting" has become much greater with the advent of the automobile; into offices, factories, theaters, churches, stores where meat, fish, fruit, vegetables, breadstuffs, cake, pastry, pickles and preserved dried-fruit, candies, confectionery, etc., form a final resting place for this germ-laden filth, which also settles on all walls, ceilings, carpets, curtains, clothes, and set freshly into circulation with each and every sweeping.

The twenty-five-cent tip to your Pullman-car-porter is nothing less than a brokerage commission for the exchange of germs between equally offending fellow-passengers. Powerful efforts for abating the dust nuisance have been successful in Europe.

The crusade began in Vienna, where a committee of citizens took up the matter; since then the movement has spread to many cities.

In our own country, Philadelphia started a similar agitation led by Professor Anders, who as chairman of the legislative

committee of the Pennsylvania Anti-Tuberculosis Society, infused great vigor into the campaign.

Circular letters of inquiry were sent to the mayors of 25 European and American cities, and the results are thus summarized by Professor Anders:

1. In a majority of the cities where results were satisfactory the principal cleaning was done at night, or completed before 6 o'clock in the morning.

2. Thorough sprinkling preceded sweeping. Sprinkling was also done two to four times daily in dry (non-freezing) weather to lay prevalent dust.

3. Flushing wagons or flushing from curb to curb with hose is the method used in preference to sprinkling and machine sweeping in the best cleaned cities. Indeed, sprinkling is seldom necessary where the streets are thus virtually washed two or three times weekly.

4. Hand sweeping by blockmen in day-time is always preceded by wetting with a hand sprinkler.

5. Piles of dirt are immediately removed while wet or damp in covered wagons.

With a better insight into the dangers from dust, a real live interest is awakening. Education has been telling; methods are improving.

In New York City, Philadelphia, and a number of other cities, modern devices for flushing have been tried or introduced. New York City appropriated $100,000 for experiments in testing the two principal methods: flushing by machine and directly from hydrants.

Remarkable is the moderate water consumption, approximating 1½ gallons per square yard for perfect work in hose-flushing, and considerably less by wagon flushing.

In Manhattan and Brooklyn (excluding Queens) it is proposed to clean by flushing 17½ million square yards with wagon flushing; this probably would not require more than 10,000,000 gallons of water, equalling about 2% of New York's daily water consumption (100 gallons per capita).

Bacteriology teaches us that germs, or spores of germs, cannot develop nor multiply without the presence of water.

Dry dust may be dangerous, but after it is moistened with ordinary water, its injurious nature is enormously increased. The addition of water merely augments and perpetuates its virulent nature. In other words, this means that the average sprinkling with insufficient amounts of water, although it may abate temporarily the dust, increases the opportunities of street infection.

Viewed from this standpoint, the average moderate sprinkling of streets is a farcical effort.

In order to make the sprinkling effective, it should either be sufficiently abundant to wash the dirt away into the sewers; or, if moderate amounts of water are used, then it becomes imperative to incorporate in the water some suitable disinfectant.

For the latter purpose, very unsuitable ingredients have been used in some European cities; for instance, carbolic acid, which produces more smell than effect, or other substances equally ill-selected, like permanganate, or organic disinfectants, which are either decidedly more expensive than chloride of lime, or lack its efficacy.

If we bear in mind what has been pointed out in the chapter on water purification, namely, that mere traces of chloride of lime exert a tremendous microbe-destroying power and that the latter is unequalled by any other commercially available substance for this purpose; if we add to this that the material is practically harmless and kills odors at the same time; if, furthermore, we take into consideration that after its oxidizing functions have been performed, nothing is left but absolutely harmless chloride of calcium, which on account of its hygroscopic nature is admittedly one of the best dust-preventives and road-binders known—then it seems strange, indeed, that in any civilized community, street sprinkling should be allowed without the use of chloride of lime.

The advisable strength for street sprinkling is one pound of chloride of lime for a sprinkling tank of 600 gallons capacity. The chloride of lime is put into the tank containing already a few inches of water which will enable it to dissolve readily while the water charge pours in. Chloride of lime dissolves easily in about 20 times its weight of water and much more speedily

in the above proportion of 1 : 5,000 water. This ratio is probably more than amply sufficient under the worst circumstances; yet it is so small that no apprehension ought to be felt when using it in such dilution for sprinkling or flushing of streets. x.

The hypochlorous acid contained in the chloride of lime ranks foremost among our powerful oxidizers; it is liberated by the action of carbonic acid, always present in water and air. This liberation, though speedy, is entirely gradual, and insures or regulates a gradual tempo of oxidation in which microörganisms with least resistance succumb first.

In other words, chloride of lime discriminates; it does practically not affect other organic matter until it has disposed of living germs and smells first.[419, 420]

But even then, as in sewage which is laden with organic bodies, after hours of contact, the residuary chlorine *stays* unused!

The germ-killing action of chloride of lime is remarkably rapid. The majority of germs are killed within the first few minutes of contact, as shown by the investigations conducted by the city of Philadelphia.[232]

In some cities with limited drinking water supply the use of river water for sprinkling and flushing streets has been resorted to. So, for instance, in New York City, provision is made by two high-power pumping stations (at foot of Gansevoort and Oliver Streets) for using water from the Hudson River.

Considering the sewage-polluted state of this water, it has been deemed advisable not to endanger the health of the people, and the feeding pipes are at present kept blocked off.

The use of chloride of lime might easily eliminate in the most thoroughgoing and simple manner any such apprehensions.

EPIDEMICS, SURGERY, AND GENERAL SANITATION.

THE following brief outline of the uses of chloride of lime in three fields involves frequent references to modes of application and quantities required.

We will therefore, at the outset, define the nature and strength of the various products.

1. Chloride of lime: the commercial dry article. (See page 9.)

2. Solution of chloride of lime in water.

Varying concentrations are referred to.

The U. S. Army regulations prescribe 6 ounces per gallon.

The French law of February 28, 1907, a 2% solution.

The German law of August 29, 1907, defines a more concentrated stock mixture, made by intimately mixing about one pound of chloride of lime with five pints of water, to be diluted as wanted.

The English Board of Trade for mercantile marine offices prescribes a 1% solution of chloride of lime, likewise the Board of Agriculture and Fisheries for cattle markets.[407]

3. Solution of sodium hypochlorite, known also as Eau de Javelle, or Javel water.

Prescription for making 2 gallons.

(Throughout this chapter, this liquid is referred to as "stock hypochlorite.")

Mix ½ lb. of chloride of lime with 1 pint of water, stirring with a wooden spoon for 15 minutes. Then add sufficient water to make 1 gallon. Next, dissolve 13 oz. of sal soda crystals or 5 oz. of soda ash, in 2 quarts of luke warm water; add to this sufficient water to make 1 gallon. Next, mix these two and allow the milky solution to settle over night (or filter). Pour off the clear liquid from the white sediment into a jug, and then fill in bottles, and keep in a cool, dark place for disinfecting purposes. A little less than two gallons of clear solution will be obtained. This "stock hypochlorite" will contain approximately the equivalent of 3% of chloride of lime, or 1% of available chlorine.

One ounce of this solution (now free from lime) to 5 gallons of

water, makes a valuable general disinfectant as well as a reliable bleaching agent for the household washing.

The great sanitary value of such stock hypochlorite solutions are unfortunately not sufficiently known.

In some municipalities they are made at public expense, as for instance, in Poplar, London, where 500 gallons of a 0.5% chlorine efficiency are made and distributed free of charge daily.

4. The term *"acid mixture"* is here introduced for *stock hypochlorite to which acetic acid or vinegar has been added.*

While in the cases of chloride of lime and stock hypochlorite, the oxidation is very gradual (this constitutes a most valuable feature) through the hypochlorous acid being liberated slowly by the action of small quantities of carbonic acid, always present in air and water, there are cases where larger amounts of *free hypochlorous acid* are desired at the outset.

This *"acid mixture"* is prepared by adding to four volumes of stock hypochlorite *one volume of vinegar.*

The mixture must be made immediately before use, as it will not keep. This solution contains as its active agent, hypochlorous acid.

Hypochlorous acid is one of the most powerful oxidizing agents known to chemists. The "acid mixture" will,[410] within a minute, kill spores which resist a 5% solution of carbolic acid for weeks.

Phelps and Johnson have shown, that in water and sewage sterilisation chloride of lime as a practical efficiency fully six times as great as had been formerly reported, and that it acts in an extremely short time.[272, 277]

In the trials conducted by the City of Philadelphia in 1910 with crude sewage, containing 2,470,000 bacteria per cubic centimeter, the bacterial reduction during the first 10 minutes of contact amounted to 99.88%, 99.90%, 99.87%, with the chloride of lime used in the proportions 1 : 32,000, 1 : 48,000, 1 : 64,-000.[232]

Other facts, of great significance, not before known, relate to the selective action of chloride of lime on the bacteria and a small range of organic bodies, while the bulk of organic matter is not readily attacked and withstands action for long periods.

Thus in the Philadelphia trials above quoted, respectively 28%, 40% and 43% of residual chlorine were found present after 60 minutes contact, notwithstanding the fact that the organic matter present in the sewage amounted to from 50 to 100 times the amount of the chloride of lime employed!

We reproduce in the abstracts an account[428] of the germicidal quality of chloride of lime when compared to that of six standard disinfectants, by Professor Delépine of Manchester, England. In these experiments chloride of lime is shown to possess 25 times the germ-killing power possessed by carbolic acid.

The pathogenic germs, with the exception of anthrax, tetanus and rabies, belong, like the typhoid bacillus, to the non-spore forming class. The typhoid bacillus, the cholera spirillum, and the various infecting agents known to cause dysentery, pneumonia and tuberculosis will readily succumb to the action of hypochlorites.[404, 410]

In the case of *scarlet fever* it is safe to place reliance only on disinfection methods which can destroy spores, and here the "acid mixture" stands indicated.

Among the large number of bacteria which produce suppuration, staphylococcus pyogeneus, streptococcus pyogeneus and diplococcus pneumoniæ, it may here again be noted that none of the ordinary pyogenic organisms form spores.[410]

Staphylococcus pyogeneus is one of the most resistant germs known. It can grow in broth cultures containing 1 part of carbolic acid in 500, but it is killed in a minute or two by an effective strength of 1 part of carbolic acid in 40.[410]

Streptococcus pyogenes has less resistance than staphylococcus pyogenes against heat and chemical disinfection. Carbolic acid (1 to 40) kills it in a minute or two, and it has not the peculiar resistance against perchloride of mercury which staphylococcus pyogenes aureus exhibits. There is probably no one microörganism which causes so many varieties of disease in man as does streptococcus pyogenes and its near allies. The majority of serious post-mortem room infections arise from such cases and they are not rarely fatal.[410]

Diplococcus pneumoniæ (Pneumococcus) is commonly, but not always, present in the mouth secretions in health. It forms no spores and is killed by heat and chemicals rather more easily than is streptococcus pyogeneus.[410-412]

Anthrax, however, is a typical example of a *spore-forming* bacillus (it forms its spores only in contact with air and not in the animal body). The spores can live in a 5% carbolic solution for many weeks; in a perchloride of mercury solution of 1 : 1000 for one to three hours, and succumb in a strong solution of chloride of lime in about 10 minutes; but in a solution containing free hypochlorous acid they are destroyed within 30 seconds.[410, 429]

The common form of human anthrax infection is by the skin; a slight abrasion becoming infected by the spores.

The tetanus bacillus also forms true spores. It is anaërobic, which explains why no danger attaches to the handling of soil where it abounds, and it develops only in deep wounds where no air can penetrate.

The same pertains also to rabies, an anaërobic, spore-forming bacterium, which likewise only developsits dangerous propagation in deep wounds caused by the bites of rabid animals.

The killing power of hypochlorous acid on spores is entirely unparalleled; for instance, sponges which have been infected with the spore-forming hay bacillus of great tenacity can not be disinfected as speedily by any other germicide.[410]

Infection ordinarily leaves the body *by the mouth* (throat secretions, sputum, etc.), *by the nose* (nasal discharges), *by the skin, in the urine,* or *in the feces.* Occasionally it may pass out by other channels, as from the conjunctivæ, or from wounds or suppurating areas.

The list of chemicals which may be employed as disinfectants is a long one, and new substances are constantly being introduced, usually with a flourish of trumpets. But the number of substances proved by experience to be of real practical utility in chemical disinfection is restricted. Professor Andrewes defines[416] a good chemical disinfectant as follows:—

1. It must be truly germicidal within a reasonable limit. For sterilising the hands and skin we require a disinfectant which will kill non-sporing bacteria in at most five minutes. For soak-

ing infected linen we want one which will kill in a few hours. The actual germicidal power must be tested by accurate laboratory experiment carried out under conditions similar to those which will be met with in actual practice.

2. It must not possess chemical properties which unfit it for ordinary use. The strong mineral acids and alkalies, though powerful disinfectants, are unfitted for everyday use by the corrosive action which they exert upon metals and other substances even in moderately weak dilution. It is a serious objection to perchloride of mercury that it damages metals, and that it forms a relatively inert compound with the albuminous substances so commonly present in material requiring disinfection.

3. It must be soluble in water, or capable of giving rise to soluble products in contact with the material to be disinfected.

4. It must not produce too injurious an effect upon the human tissues with which it comes in contact. It is too much to ask that it should be non-poisonous to man, but the less poisonous it is, the greater its sphere of utility as a gargle or internal disinfectant, and the less the dangers that will follow its external application to wounds. Carbolic acid in efficient germicidal strength produces an unpleasant effect even upon the healthy skin if the immersion is too prolonged or too frequently repeated, and the same is true of perchloride of mercury.

5. It must not be too costly in proportion to its germicidal value. It is evident that a substance which will be efficient in a strength of 1 in 1,000 can afford to be fifty times dearer than one which will be efficient only in a strength of 1 in 20.

Though medical literature has pointed to merits in chloride of lime ever since in 1846 Semmelweiss succeeded in stamping out by its means the Vienna endemic puerpural fever, only of late have the applications of hypochlorite become more generally established.

Unlike corrosive sublimate, it is non-coagulant; it directly breaks down the serum envelope of the germ and destroys the microörganism by oxidation. This also explains why removal of blood and all foreign matter is accomplished with so little effort, and the use of a soap and water wash becomes eliminated.

For wounds, lacerations, ulcers, cancerous sores, scrofulous

enlargements, also for cutaneous eruptions (especially itch), stock hypochlorite of strength as described should be used.[422, 423]

For putrid sore throat, diseased gums, mouth wash, gargle, dilute 1 to 6.[422, 423]

Hypochlorite solution is absolutely unequalled for sterilization of *bandages, and all dressings* (cotton-wool, wood wool, gauze, etc.), which act as germ-excluders. (It is well to bear in mind, that the albuminous discharges from wounds greatly hinder the disinfectant action of the salts of mercury.) Besides, a decided bleaching effect is produced where the materials used are stained. Dilute 1 to 10.

For sponge bath, general toilet use. Dilute 1 to 10.

Cleaning or washing of sick rooms: Dilute 1 to 20.

For the removal of coagulated blood from the skin, operating tables, etc., use full strength.

Cleaning of Sponges. Clearly the strong solutions, but not so strong that they injure the sponges, should be used. It has been observed that sterilization was obtained after an hour's soaking in solutions containing hypochlorous acid of about half the strength of our "*acid mixture.*"[410]

For excreta, urine, pus discharges from wounds, for sputum, vomits, and other secretions, chloride of lime is a most suitable disinfectant.[422, 424]

These secretions should be intimately mixed with twice their amount of a 1% solution of chloride of lime, and then not be removed into the water-closet before an hour has elapsed.

Bichloride of mercury is unsuitable for this purpose, because it combines with the albuminous bodies contained in these secretions, and forms inert, insoluble substances, and the effect is practically wasted. Cultures of staphylococcus aureus cannot be completely disinfected in bichloride of mercury for this reason, unless a very large excess should be taken and long time allowed for action.

Carbolic acid in contact with those secretions, is not in any manner of means to be compared in efficiency to chloride of lime solution, which mixes readily with all secretions and reaches every particle.

For practical use no other chemical can compare with chloride

of lime in the disinfection of sputum. Carbolic acid and bichloride of mercury coagulate the sputa and hinder the access of the disinfectant to the central parts of the masses, but chloride of lime solutions break them up and dissolve them. Nissen found that a solution of the strength of *1 part in 500* killed staphylococcus pyogeneus aureus in one minute.[429]

In spinal meningitis it is believed that the channel of infection is chiefly by the nasal passages, and to these, and the throat, attention may chiefly be directed as regards measures of disinfection. It forms no spores and is easily destroyed outside the body.

In acute pneumonia, though this disease is present in the secretions of the respiratory tract in the majority of healthy persons, the secretions should be disinfected with 1% solution of chloride of lime.

Modern opinion is gradually coming to lay more stress on the danger of the throat secretions, and less on the peeling epidermis in *scarlet fever;* and it is safe to place reliance only on disinfectant measures which can destroy spores. The mixture containing free hypochlorous acid should be used.[410]

Tuberculosis sputum, with its billions of bacilli, can be disinfected by mixing intimately with strong solution of chloride of lime.[405, 422]

Hands. For the final cleansing of the skin, the "acid mixture" is the most powerful agent. After handling patient, or any infected object, bedpans, sputum cup, etc., wash two minutes in stock hypochlorite.[410, 422]

Water from bath given to patient, or used for washing the person; sterilize with one tablespoonful stock hypochlorite to every gallon; and allow 20 minutes contact.

Glassware, crockery, tablespoons and forks used in sick rooms should be deposited into a 1 to 10% solution of stock hypochlorite after use, before they are taken down to be washed.

Linen (bed, body, towels, sheets, underwear, soiled with pus, excreta, blood). By immersing for two hours into a solution of stock hypochlorite (1 to 7), the articles will be made perfectly free from germs. If they are soiled with pus, excreta and blood, the powerful dissolving quality of the solution will aid

in their removal, and not allow, as is the case with corrosive sublimate, the articles to become stained.

For colored goods, or articles of wool or silk a dilution of 1 to 70 is recommended, to protect the colors from being seriously affected; in this case a second soaking in a fresh amount of the very weak solution is required; each immersion to last one hour. Cases are on record in which cholera has been conveyed to laundry employees by infected linen.

Tables, floors, chairs, walls, wooden bedsteads, use 1 to 10 stock hypochlorite. Saturate the surfaces with a mop and let dry.

Brushes and combs used in sick rooms. Brushes to be washed in soap and water adding some ammonia. After washing they are to be laid into 10% stock hypochlorite solution and left for one hour.

Regulations here and abroad were framed before the true germicidal value of chloride of lime had been determined, and its contrast to other standard disinfectants is indeed much greater than appears in laws made five years ago.

Our Federal Government has not formulated any regulations. The U. S. Army standard solution is 6 ounces chloride of lime to 1 gallon of water.

In an order of the Board of Agriculture and Fisheries of England, of April 5, 1906,[407] cited as the Diseases of Animals (Disinfection) order of 1906, dealing with glanders and foot and mouth diseases, it is specified that:

"The place or the thing or the part thereof shall be thoroughly coated or washed with

"a. A 1% solution of chloride of lime, containing not less than 30% of available chlorine, or

"b. A 5% minimum solution of carbolic acid, containing minimum 95% pure acid, or

"c. A disinfectant equal in disinfectant efficiency to the above-mentioned solutions; in all cases a thorough sprinkling with lime wash to follow."

In the swine fever order, 1908, similar regulations are ordered by the same board.

In the Board of Trade instructions to superintendents of

mercantile marine offices, dated February, 1907, disinfectants are scheduled in the same order.[407]

The French law of February 28, 1907, prescribes a 2% chloride of lime solution.

Under the German Government instructions the chloride of lime is to be gradually mixed with five times its own weight of water until the whole mass is in a homogeneous state without lumps, and this concentrated form to be diluted afterward in order to serve its manifold purposes; for instance, a 1% solution of chloride of lime is to be used for washing holds, etc., on board ship.

All these prescriptions, however, emanate from the time before our recent knowledge about chloride of lime had been at hand, and without doubt are all excessive in strength. But even then the cost of chloride of lime stands at only one fortieth that of carbolic acid for doing the same work.

In the sanitation of public buildings, used as schools, assembly rooms, barracks, churches, theatres, fairs, storage houses, markets, etc., no fumigation will supplant what must be done by washing and scrubbing.

Let us not mince matters: Disease germs do not float in air, they repose on surfaces. That disinfectant, which in following soap mixes readily with suds and water, penetrates objects in same manner as they do, fills the demand. This explains why hypochlorite solutions are so superior in every kind of sanitary scrubbing and cleaning; in their possibility of use in extreme dilution and cheapness, and their penetrating power lies the reason why they are being more universally accepted.

Slaughterhouses, bakehouses, dairies, and premises used for milk trade should be disinfected after washing in the same manner. Slaughterhouses are particularly difficult to disinfect by other means on account of the large amount of albuminoid matters present.

With reference to cattle cars and baggage cars, the former are disinfected after each journey, and the latter after they have carried putrescible or suspected substances, with, in each case, a previous thorough cleaning. It has been shown that even after the most careful cleaning with very hot water, there remains

an organic film which requires repeated irrigation with a very active disinfectant. Chloride of lime as well as hypochlorite of sodium in diluted solution have been successfully employed for this purpose, a simple spraying apparatus being used.

Disinfection of houses is rarely required, except in cases of contagious diseases. Fresh air, light and frequent cleaning are then the essentials. After washing floors, walls, stairs, sinks, furniture, bedsteads with soap and water, a weak stock hypochlorite, diluted 1 : 10, should be used for mopping or spraying. The solution is allowed to dry.

Chloride of lime is known to be a most efficient deodorizer, indeed, in coming in contact with any substance, it destroys odors as well as bacteria. For mouldy cellars, murky backyards, dark, dusty places, often the abode of tubercular germs, there is no better remedy than sprinkling with chloride of lime.

CHLORIDE OF LIME ON THE FARM.

LET us briefly touch upon the far-reaching uses chloride of lime can find in country life:

In the dairy; for securing pure drinking water; in much that pertains to success in keeping cattle and domestic animals; the disposal of excreta; in the laundry for cleanliness; in kitchen, pantry and storerooms; for cleaning seeds, as a spray for shrubs, trees; and in cases of plant diseases generally; for exterminating the house fly; in first aid in accidents; in fact, in all than can befall man and animal life through malignant germs; in other words, for obtaining unprecedented salubrity in the home and on the farm generally, the farmer should have recourse to this invaluable expedient.

Milk leaving the farm should not carry typhoid germs into some home, or give summer diarrhœa to some one's child, as is frequently the case through criminal carelessness.

Sterilization of the Rinsing Water Used in the Dairy.

For fifty gallons of water use ½-pint stock hypochlorite. (See page 53.) All vessels before they finally receive milk should be rinsed out with this sterilized water, which will completely set at rest all question of typhoid germs that might be in the water.

What becomes of the milk later on after it has left the farm is not for the milk producer to worry about; but he has certainly to do his duty, and he has no excuse for continuing in an irresponsible way endangering lives of consumers and children by delivering the milk which had disease germs in it from the very start.

Milk as it leaves the udder contains practically no germs; it is from the water with which the milk pails, milk cans, bottles, etc., are rinsed that the danger arises.

Milk marketed or kept in bottles or cans rinsed out as directed with sterilized water, naturally will show better keeping qualities and will not turn sour as readily as in containers washed with ordinary water.[112]

Only a year ago the English government published the sen-

sational facts about the typhoid carrier. (See page 39) It is now known that in a city like New York, there are always between 15,000 and 50,000 seemingly healthy persons who discharge typhoid germs in their excrements. In the country where there is no sewage disposal, the soil is charged with typhoid, and so are most country wells.

Contaminated milk is much blamed as one of the causes of infant diarrhœa. Among 25 children who die of it, as a rule only one is breast-fed by the mother. The infection may be caused, for instance, by flies falling into the milk. Flies feed on all kinds of abominable filth, excreta, etc., and can infect the milk in which they fall several weeks after they themselves have become infected. Dust is likewise a great carrier for diarrhœa germs.

The ignorance and carelessness of the average farmer is appalling, and we cannot put the case too strongly in branding his negligence for being accountable for the loss of so many lives. In Dutch cities, most mothers feed their own children and the infant mortality of children under one year (mostly from diarrhœa) is 75 per 1,000; in Fall River, Massachusetts, it is 190.

Flies smell foul garbage from a long distance. They congregate there, use it as a breeding place, and then go somewhere else where they infect milk, food supplies, children's eyes, animals, etc. Sprinkling with a little chloride of lime keeps them away and prevents fouling. It is a fortuitous fact that refuse must accumulate before it starts to foul so as to become a breeding place; on account of this breeding places can be readily found, then disinfected by chloride of lime and destroyed. (See chapter on the fly pest page 68.)

Sanitary privy. The most frequent cause of infection in the country is the privy. The admirable work done in the South by Dr. Stiles should induce everybody living in the country to get the government publications dealing with the subject.[318-320] However, let us be thankful that, for controlling all sanitary defects, a remedy has come to us, though at present we may not be prepared to stop their source. By means of chloride of lime it certainly is possible to bring about in water sanitation, sewage disposal, fly extermination, garbage and refuse control, etc., a degree of sanitary safety undreamt of only a few years ago.

Water and Sewage Sterilization in the Country.

Drinking water in over 100 cities is now being sterilized by chloride of lime, in the proportion of about 8–16 pounds to a million gallons of water. (See page 12 and following.)

Two fluid drams of the stock hypochlorite to a barrel (50 gallons) of water will render water perfectly safe, and free from all disease germs.

It is very easy to sterilize small quantities of water in the household, or when on a journey:

Dissolve in a pint of water, half a teaspoonful of chloride of lime by first rubbing the powder with a little water to a cream-like mass, and then adding more water to make up one pint. (For measuring the half teaspoonful, place a moderately heaped teaspoonful on a piece of paper and divide in two equal parts.)

Of this solution, one tablespoonful will sterilize 10 gallons of water, or 36 drops one gallon, which will render any water pure and wholesome. For one quart, add 9 drops of the solution, which should be freshly prepared every day.

Swimming pools. Many cases of typhoid fever have been contracted by bathing in polluted brooks and in ornamental ponds near homes. These can be rendered harmless at a trifling cost by very small quantities of chloride of lime.[113-120]

Sewage. In sterilization of city sewage, the quantity usually employed is one part of chloride of lime to from 25,000 to 50,000 parts of screened sewage. City sewage naturally is relatively dilute on account of the large amount of water consumed by the inhabitants thereof. In New York City, 100 gallons a day per capita is used; in Chicago 230 gallons; in London 47 gallons. (p. 31.) The blessings of sewage sterilization by chloride of lime are now rapidly extending to small communities, institutions, etc., and may in the near future play a very important rôle in the sanitation of country life.

Stables. Animals will be more efficient and make more weight in sanitary surroundings. In some parts of Europe, the sanitation of stables is attended to with much care. In some places, all the cattle are entirely removed from the stable once a week, and after a thorough sweeping, the floor and walls are thoroughly

flushed. In this way, the significant fact, that flies require eight to ten days development in breeding, is turned to good account.

For flushing floors and walls chloride of lime in the same dilution as indicated for street flushing is used: namely, one pound for 600 gallons. It is very important once a week, also, to scrub and disinfect the troughs, using the same dilution of chloride of lime. Eminent veterinarians prescribe for walls, pillars, etc., whitewash containing 1% chloride of lime.

Domestic animals stand in the same need of cleaning that we do. Many a child has caught diphtheria from contact with chickens, dogs, cats, etc., while scarlet fever and tuberculosis germs often abound with such pets. For washing dogs use stock hypochlorite (see page 53), 1 to 6 dilution, at the finish.

Barns, alleys, courtyards, etc., require repeated copious flushing with the same dilute mixture, containing only 1 pound of chloride of lime in 600 gallons of water, or about 1:5,000.

Manure heaps. Present day methods cause a loss of about $12 per head of cattle through rotting and loss of fertilizing value. Besides, the flies breed and carry infection everywhere. All this can be remedied in a manner which is described in the separate chapter on the fly pest, (see page 68) the careful perusal of which we recommend.

Vegetables reach us loaded with bacteria, which is only natural, as farm soil often contains about 20,000 germs in 1 grain. Only of late, has it become known that typhoid bacilli in human excreta are much more frequent than was formerly supposed.[32]

With vegetables we must trust to boiling, but when it comes to salads, endive, celery, lettuce, onions, cucumbers, then more reliable methods are advised than in use at present.

These articles of food, after washing, should be rinsed in a very dilute solution of stock hypochlorite (one teaspoonful in a large bowl of water). This extreme dilution has no effect on the taste or on the food value of the salads which can be eaten without hesitation.

Washing furniture. Tables, floors, chairs, walls, etc., in the places where bread is baked, and where meat is handled, in the kitchen, pantry, scullery, etc., should be followed by mopping

with a weak solution of chloride of lime, 1:5,000. This will render everything safe, sweet and salubrious.

Moulding, smelling cellars require sprinkling with some chloride of lime which acts as a most efficient deodorizer.

Laundry. A wineglassful of stock hypochlorite to one wash boiler of 10 gallons, is ample not only to secure the whiteness of the linen but to cause thorough disinfection. Whenever linen rots from the use of chloride of lime it is on account of excessive or careless use.

THE WAR AGAINST THE INFECTIOUS HOUSE FLY.

A GREAT awakening has recently taken place to the tremendous influence which the common house fly has upon public health. This insignificant little insect is now known to be one of the most prolific carriers of disease in numerous unsuspected ways.

The agency of the house fly in the spreading of such diseases as typhoid, infant diarrhœa, tuberculosis, ophthalmia, infantile paralysis, and others too loathsome to mention, continually looms up in the more recent study of problems of public sanitation.[294, 371]

Destroy the house fly in a given community, and immediately you reduce typhoid fever and infantile mortality. This potent fact can not be too strongly emphasized.

The vast benefits derived by any community from sanitation through rational cleanliness, include an increase of efficiency of the citizens; leaving ethics and esthetics aside, the monetary outlay of such a campaign of scientific cleanliness, be it what it may, is insignificant, compared to the economic gain of the community.

That such a campaign can be successfully carried is now an accepted fact.

The relation between sanitation and efficiency has never yet had an illustration so forceful, as in the rapid progress made with the construction of the Panama Canal.

What is most striking is that the problem of insect-extermination and systematic sanitation, at the Canal Zone was solved by means astonishingly simple and quite commonplace in detail.[376]

When in May, 1904, Colonel Gorgas appeared on the scene, the country presented a desolate picture of dilapidation, business depression, financial failure and general discouragement. Jungle had everywhere grown over the railroad track, water came flowing out from every ravine or was found stagnant in swampy pools.

Malaria, dysentery, beriberi, were rampant among the poverty

stricken, simply aimless populace of the twenty odd villages along the line and in the two terminal cities of Panama and Colon, where they drank rainwater, of which a four-month supply for the dry season had to be saved in numberless barrels, tanks and receptacles of every kind.

With the tropical temperature varying little between January and July, the Anophele and Stegomyia mosquitoes were everywhere in abundant evidence, and their breeding places covered every yard from coast to coast.

Into this pest jungle an industrial army of 40,000 men was to be introduced and Colonel Gorgas had to make up his mind quickly what should be done for protecting their lives.

He with his associates drew up plans to meet the situation, mainly aiming at demolishing breeding places.

There was to be:

1. Burning all brush and jungle.

2. Cutting brush and grass within a measured distance of every dwelling.

3. Laying dry all pools by ditching and draining and filling up.

4. Oiling with crude petroleum all ditches, pools, etc.

5. Intercepting waters from ravines and directing into proper courses.

6. Regulating gutters on buildings to secure complete drainage. Indentations preventing such drainage were punched.

7. Making all drinking water barrels and cisterns mosquito proof by painting and screening.

8. Screening all windows or openings to dwellings.

9. Systematic search for breeding places of mosquitoes, with abundant disinfection for killing the larvæ.

In the beginning, for subduing yellow fever, the towns were divided into small districts, such that an inspector could get around to each house twice a week. On his report some men would be sent to the house to make all water barrels, cisterns and gutters mosquito proof. A record was kept of all unacclimatized people in the city and houses occupied by them were visited daily by an inspector, who reported to the health department at once any person found ill.

In addition, ditching, oiling and draining was done in the suburbs.

With these simple means enforced by rigid and unremitting inspection and policing all through the Zone, this great work, the like of which the world had not seen before, inaugurated a new epoch from which dates the real acclimation of the Caucasian in the tropics.

An account of these activities during 1911 will be of interest:

	Panama	*Colon*	*Christobal*	*Mt. Hope*	*Toro Point*
Ditches cleaned. (lin. feet)	1,512,737	110,564	7,944	210,064	102,192
Ditches dug. (lin. feet)	18,287	6,974	11,383	21,832	55,516
Weeds and grass cut. (sq. feet)	2,071,350	5,880,000	3,200	....	315,000
Brush cut and burned. (sq. feet)	1,140,000	....	......	....	....
Gutters repaired or lin. feet punched	15,031	....	......	....	....
Gutters removed. (lin. feet)	5,118	....	......	....	....
Rats caught	13,497	....	......	....	....
Mosquito breeding places found	....	2,982	476	1,975	1,602
Crabholes found worked	....	36,600	900	14,815	45,642
Water receptacles treated	....	339,710	51,740	703,325	89,543
Pools oiled. (sq. yards)	....	226,276	44,298	456,648	513,770

If the mosquito is a source of infection, so much the more is the ever-present house fly to be dreaded as the relentlessly deadly enemy of the human race.

On anyone failing to realize the importance of the fly question when thus paralleled with Colonel Gorgas's problem in 1904, a few recent facts from only one of the practically unknown or unconsidered fields should make an impression, facts relating to the human "Typhoid Carrier."[32-36]

Upon Koch's recommendations, bacteriological stations were established in southwest Germany for studying this question. Doctor Frosch was appointed to the first station at Trier. There are now altogether eleven, each having a director, two or three bacteriologists and some attendants. Frosch, discussing a series of 6,708 typhoid cases shows that 144 (2.15%) became transitory and 166 (2.47%) chronic "typhoid carriers," in other words the patients after being cured, carried a contagion along to healthy persons with whom they lived.[32]

The meaning of this may be best shown from investigations by others among the general population, where healthy persons only were examined. Klinger found[32] among persons living in

the neighborhood of actual cases, 8.8 typhoid carriers per 1,000.

Rosenau, Lumsden and Kastle found among people in Washington, 3 typhoid carriers per 1,000.[32]

Minelli found in an institution in a city free of typhoid, 5 typhoid carriers per 1,000.[32]

These figures, applied to any given center of population, for instance the city of Cleveland, would mean, that in Cleveland, there walk about respectively 5,280 or 1,800, or 3,000 apparently healthy persons, who in their feces, or other secretions, discharge typhoid bacilli, and are a permanent source of infection to all who live with them or near them.

More evidence on infection by flies, will be found in the abstracts.[291-376] Present-day sanitarians accuse the house fly of being the main cause for the high "Residuary Typhoid Rates" in American cities, and thus explain, in a large measure, the typhoid death-rate in cities where a perfectly pure supply of drinking water has been provided.[350]

During the last few years we have been placed in possession of some startling facts on the house fly, fully confirming the valuable work done by such men as Dr. Howard, Chief of our National Bureau of Entomology in Washington;[371] Professor Nuttall, formerly of Johns Hopkins, now in Cambridge, England;[370] D. D. Jackson, director of the Laboratories of the Water Board of New York City, and a number of others.[294, 297, 298]

In England, Parliament granted large sums for investigations which have covered the subject in all its phases and the outcome of which are four special reports to the Local Government Board. In the fourth report (new series No. 53, 1911), Professor Graham-Smith of Cambridge, definitely proves that infected flies will infect fluids, such as milk and syrup on which they feed, and in which they fall, and will do so many days after they were themselves infected.[305] See also report of Dr. Newsholme.[330]

A brief summary of biological facts about the house fly, pertaining to its danger and its control, will not be out of place in this volume. Any information of the kind will be useful to the sanitarian in his fight with ignorance and incompetence.

Flies deposit their eggs upon garbage, manure, human excreta and similar material; the maggots hatch in less than twenty-four hours; are full grown in about five to seven days, and are forthwith transformed to an oval brown pupa, remaining in this resting condition five to seven days. The fly then leaves the pupa in a full grown state.

For purposes of extermination in breeding places, it is important to bear in mind, that the whole life is usually completed within ten to fourteen days, the shorter period pertaining to warmer surroundings.

One fly may deposit about 120 eggs and become the progenitor of many millions during one season.

Flies feed on vegetable matter, preferably when fermenting or decaying, garbage, manure, especially human, rotten flock beds, straw mattresses, old cotton garments, socks, waste paper, bread, fruit, vegetables, sputum, parasitic worms, even evacuated worms, putrid meat, slaughterhouse waste, rotten chicken feathers, chicken manure, cow dung, and, of course, milk, sweets, butter, lard, every kind of food, everything accessible in our pantries, kitchen, dining rooms, our children's meals, table delicacies, etc.

When discharges from typhoid fever patients are exposed, any flies present pounce upon it for a meal; they swallow countless numbers of the deadly bacilli, and their hairy legs are fouled with thousands more. Jackson counted on 18 flies, eighteen and a half million germs, more than one million to each fly![297]

Astonishing is the length of time for which they will retain pathogenic bacteria in full virulence, not only on their legs, etc., but they ingest tuberculous, typhoid, dysentery, anthrax, etc., germs and pass them even weeks after their own infection.

Loaded with ophthalmia and gonorrhœa, they settle on the eyes and mouths of infants; or they deposit with their excreta, eggs of tape worms, and round worms which pass through them unaltered, after having been sucked up and devoured by them.

Their feeding on the stools of patients sick with cholera, dysentery, infantile diarrhœa, typhoid; on tuberculous sputum; on the sores from small pox, tropical sore, bubonic plague; has long been known, yet people cannot yet break with an old habit,

cannot begin to pay attention to a seemingly harmless little insect, familiar to them since their childhood days.

If we could see in its true light, the house fly as it stalks about with its hundreds of thousands of adhering bacteria, breeders of the most contagious, the most loathsome diseases, the fight would be half won. But the limited imagination of the mind untrained to scientific observation fails to realize the fearful danger resulting from these bacteria which are carried about unseen on this seemingly insignificant and familiar insect, which is accepted as a matter of course.

Fortunately, several physiological traits, inherent to the habits and development of the fly, come to our aid in our war of extermination.

Flies breed in accumulated garbage, waste, manure, etc., which is in a state of fermentation or putrefaction. Hence, such breeding places are not difficult to locate.

It is known also that by sprinkling with chloride of lime, fermentation or putrefaction, is arrested; furthermore, this can be accomplished without the necessity of immediately removing the decaying matter.

Moreover, the range of flight of flies has of late been studied by the English investigators, Copeman, Howlett, and Merriman, under an appropriation by the Local Government Board for England and Wales;[306] it was found that flies mostly move within a limited circle of about three quarters of a mile radius from breeding places; although they are attracted to refuse deposits even across rivers and hills.

The time intervening between the laying of eggs and the emerging of the adult fly from the pupa is 8 to 10 days; within this period, removal and thorough sprinkling with chloride of lime should prevent the adult fly from making its appearance.

For a better understanding of the problem how to carry on the war against the house fly, let us consider town and country separately. In the country, the individual has control over his own ground and needs nobody's consent, for making a start in good sanitation; he can do on his own initiative what sooner or later is bound to be insisted upon by the health authorities as an essential sanitary ordinance.

The main point we wish to bring out is that one careless householder may cause flies emanating from his place to infect a neighboring area three-quarters of a mile in radius; this area being limited by the life habits of the fly. On this account individuals have it in their power, in a large measure, to rid their own neighborhood from this pest; by doing so, they may create a public sentiment which will help the board of health in extending the work. All our states have unlimited discretionary power in matters relating to public health, and the local health boards can delegate this power to any public-spirited citizen giving him authority to act as special local inspector.

Aside from searching, disinfecting and removing of garbage and refuse, it is in the disposal of animal manure that the fly pest can be most efficiently abated in the country. For dealing efficiently with the evil, the following steps must be taken:

1. Removal of manure from the stables once a week in winter and twice a week in summer, followed by a careful sprinkling of the floor with chloride of lime. By limiting the intervals within eight days, the manure is removed within the period of incubation, and all larvæ on the floor are killed by the chloride of lime, which is a powerful maggot killer.

2. The manure should be removed and stored into fly-tight pits or vaults, on which subject we cite the ordinance now in force for the District of Columbia:

"This bin shall be so constructed as to exclude rainwater and shall in all other respects be water tight, except as it may be connected with the public sewer. It shall be provided with a suitable cover and constructed so as to prevent the ingress and egress of flies."[71]

The average horse manure to be disposed of equals 8 quarts per day, or 15 gallons per week per horse.

3. The campaign against the house fly may become instrumental in doing away with the present enormous losses of fertilizing value through improper storing. To take a concrete example: ten tons of fresh manure and litter, containing 4,250 pounds of organic matter, may be made to contain at the end of four months about 3,600 lbs. by proper storing, or only 2,100 lbs. by improper storing.

Manure collected in heaps undergoes peculiar changes caused by bacteria, by which it is altered and ripened sometimes becoming intensely hot and giving off vapors. In this process of breaking up the tissues and nitrogenous compounds by the bacteria, much heat is generated and ammonia, of high fertilizing value, is set free.

It has ever been the endeavor of the agricultural chemist to avoid this loss, and it has been proven by him that manure kept in a container, and stamped into a compact mass, will preserve a much higher fertilizing value.

In the city, the individual initiative of the inhabitants is also of the highest importance. Without an intelligent and conscientious coöperation of the individual citizen, the great power invested in the board of health cannot work for the full benefit of the community.

It is a crying shame to see in some cities here and abroad, carts with putrefying garbage passing through the streets and developing most obnoxious smells. This practice is tolerated by sheer custom. But the odor, itself, is not the worst offense: The decaying garbage in open carts is transported through our streets as if it were a contrivance invented for the very purpose of carrying infection to ourselves, to our children, to everything that lives, by the agency of the fly.

The boards of health should awaken to their grave responsibility by compelling the householders not to deliver any garbage before it is disinfected. There are but two remedies for it: either to compel them to burn up their garbage, which is awkward and expensive, or the next, and cheapest and simplest way is to sprinkle a small amount of dry chloride of lime on the garbage cans. Every garbage can, after being emptied should be disinfected by sprinkling chloride of lime at the bottom. The latter precaution could be taken by the garbage collector, who ought regularly to be provided with chloride of lime, which should also be sprinkled on the garbage as it is loaded into the cart.

During the day, the householder should be taught, upon each addition to the garbage pail, to sprinkle a little chloride of lime on the surface. In this manner, putrefaction would be entirely prevented and the garbage can would cease to attract flies.

With the investigations on the flight of flies, by Professor Copeman and other experts,[306-308] more insight has been gained into the faculty of the house fly, to scent fermenting or foul smelling material at a distance. Not only is decaying refuse a preferred breeding ground, but flies hasten to it from all sides from every manner of place. If we intended to secure a collection of flies carrying every accessible variety of infection within a certain radius, we would simply have to expose an ill-smelling garbage can to attract them first; there may be nothing infectious in that rotting garbage, but the danger emanates from the place where the flies have been before. A garbage can is a clearing house for infection and no householder who has given the necessary attention to such facts as we are placing before him, will make light of his responsibility in distributing disease when in one single recorded experiment, 414 flies caught at random were found to carry germs at the average rate of 1,222,570 bacteria for each fly.[303]

D. D. Jackson (1909),[25] in his report to the Merchants' Association of New York, shows that the sewage is not carried away by the tides and "that at many points, sewer outfalls have not been carried below the low-water mark, in consequence of which the solid matters from the sewers have been exposed on the shores." These deposits were found to be covered with flies thus affording ample opportunity for the transmission of typhoid. It was furthermore reported that the greater number of typhoid cases were found near the water front, and if the curve showing the prevalence of cases was set back two months it coincided with the curve showing the prevalence of house flies; the period of two months represents the time of incubation. The fly curve, of course, also coincides with the temperature curve, but hot weather alone cannot account for the dissemination of the typhoid bacillus.

The example of San Antonio, Texas,[371] cited by Dr. Howard, where Dr. J. S. Langford enlisted the school children in a mosquito campaign, should not be left unmentioned here, as the mortality of the city from malarial trouble was reduced 75% the first year after the work was begun, and in the second year it was entirely eliminated from San Antonio. Teachers and the

populace had become intensely interested, and such a rivalry sprung up in the city for finding and reporting to the board of health the greatest number of breeding places that the malarial scourge was wiped out in two years.

To meet the situation in a thoroughgoing manner, the boards of health should buy chloride of lime at wholesale prices and distribute at cost or at a very small profit, to individual householders.

In most of the abstracts which follow, titles, either in full or abbreviated, have been inserted before each reference in larger type so as to facilitate location. In the case of the journals which are quoted most often the place of publication is omitted, but this will be understood for the *Engineering News*, *Engineering Record* and *Municipal Journal* to be New York, and for the *Journal of the Society of Chemical Industry* to be London. The numbers preceding the title of each reference correspond to the reference numbers in the text of the book.

ABSTRACTS AND REFERENCES.

SEWAGE POLLUTION.

1. Pollution of Streams by Sewage.

HORTON, THEODORE, Chief Engineer, New York State Department of Health. *Twenty-ninth Annual Report*, New York State Department of Health, Vol. 2, Albany, 1908.

Conclusions (condensed):

1. That the discharge of domestic sewage into a stream may become dangerous to health, when it is derived from a community in which communicable diseases have been prevalent. Communicable diseases are more or less prevalent in all communities.

2. That the discharge of domestic sewage into a stream may, in addition to danger to health, become a source of offense or nuisance, when the available oxygen carried in the sewage or in the stream into which it is discharged, is insufficient to prevent aërobic conditions, in which case putrefactive and offensive odors are given off.

3. That industrial wastes in themselves, and unmixed with domestic sewage rarely, if ever, contain pathogenic bacteria.

4. That industrial wastes may occasionally contain poisonous ingredients that may inhabit and kill fish and other forms of life, such for instance as bacterial life, under which condition the actual agency of purification and nitrification is arrested.

5. That industrial wastes may become the source of serious nuisance through emanation of offensive gases resulting from anaërobic or septic action.

These offensive gases may emanate from deposits of organic matter along the bed and banks of the stream, or they may emanate from the surface of the water itself.

2. The Selection of a Water Supply.

OGDEN, H. N. *Twenty-ninth Annual Report*. New York State Department of Health, Vol. 1, p. 773–796, Albany, 1908.

3. A Committee on Standards of Purity for Rivers and Waterways.

Engineering News, Vol. 66, p. 785, 1911.

The above committee has been announced by Mr. Calvin W. Hendrick, president of the National Association for Preventing the Pollution of Rivers and Waterways, and chief engineer of the Baltimore Sewage Commission, Baltimore, Md. This committee was organized at the meeting of the Association held at Baltimore on December 31, 1911. The committee was instruc-

ted to study in a broad way the subject indicated by its title and to make a tentative report at the next annual meeting of the Association. This report will deal with the question of the feasibility of establishing standards of pollution applicable to the conditions prevailing in various parts of the country. The names of the committee are as follows:

WHIPPLE, GEORGE C., of Hazen and Whipple, 103 Park Ave., New York City.

BARTOW, DR. EDWARD, Director, Illinois State Water Survey, Urbana, Ill.

WIESNER, GEORGE M., Chief Engineer, Sanitary District of Chicago.

CLARK, H. W., Chemist, Massachusetts State Board of Health, Boston, Mass.

McLAUGHLIN, DR. A. J., of the U S. Public Health and Marine-Hospital Service, Washington, D. C.

4. Stream Pollution.

PHELPS, EARLE B. Disinfection of Sewage and Sewage Effluents; from a paper, read before the American Society of Municipal Improvements:

It often happens that while typhoid fever is raging in one community, the next community down-stream has between its drinking water and the necessarily infected waters of the river only a poor water filter, oftentimes broken down or greatly overworked. The margin of safety here is too small. It is manifestly unjust to throw upon any water filter the burden of purifying a stream which is being seriously and wilfully polluted and infected by others. This is the position which is being taken by the more advanced of our states, as shown by legislative enactments. It is the position universal among the best sanitarians of the day, and, finally, it is the position dictated by ordinary common sense and by an ordinary spirit of engineering caution. Therefore, it does not seem that one will be charged with undue enthusiasm who holds that, since it is now possible and perfectly feasible to prevent the discharge of pathogenic germs through the sewers of cities into drinking water supplies of other communities or upon important shellfish areas, such steps should be taken and will in the very near future be considered essential.

5. A Review of Laws Forbidding Pollution of Inland Waters in the United States.

GOODELL, EDW. BURPEE, *Water Supply Paper*, No. 152, 2d ed., U. S. Geological Survey, Washington, 1905.

6. A British Decision Regarding River Pollution.

Engineering Record, Vol. 61, p. 586–588, 1910.

7. Water Pollution Control in Ohio.

Engineering News, Vol. 68, No. 1, 1911.

The State Supreme Court upholds the authority of the State Board of Health to compel the cities and villages of Ohio to establish sewage purification plants,

on finding that water pollution, constituting a public nuisance detrimental to health, is being created.

Thereby an injuction-suit against the State Board, brought by the City of Greenville, has been defeated.

8. Typhoid Epidemic

At Coatesville, Pa., the direction of the State Commissioner of Health that a hypochlorite plant be installed was not heeded, and a few weeks later (January, 1912) a severe typhoid epidemic broke out. It was promptly checked by Health Commissioner Dixon sending the engineer of his department to do the work.

9. Sanitation of Cities.

BERAULT, B. Assainissement des Villes: Annuaire-Stastique International des Installations d'Epuration d'Eaux d'Egouts au 1 Juillet 1911, en Allemagne, Australie, Argentine, Autriche-Hongrie, etc. Avec les Lois et Reglements en vigeur au sujet de cette question dans la pluspart de ces pays. 174 p. Paris, 1912. (Sanitation of Cities. International Statistical Annual, showing Installations for Water Purification up to July 1, 1911, in the various countries, alphabetically arranged. Also the laws and ordinances in force on this subject in most of the countries.)

10. Typhoid Outbreak, Cedar Falls, Iowa.

GROVER, A. L., and DOLE, R. B. *Engineering News*, Vol. 67, p. 526–527, 1912.

Careful investigation showed that milk, oysters, vegetables, ice-cream, and butter had to be excluded as possible sources of infection.

The close relationship between rainfall, flood and onset of the disease pointed to the infection of the water supply which is taken from springs, issuing from limestone, one or two feet above the level of a water course called the Dry Run.

The epidemiological study conclusively supports this view and the sanitary survey of the watershed revealed several opportunities for contamination.

Chemical and bacteriological examination of water should be regarded only as supplementing evidence, and no supply should be pronounced safe to drink on the basis of a few laboratory tests.

11. Contamination of Surface Waters.

HYDE, CHAS. G. Paper presented to the League of California Municipalities, October 26, 1911:

"Particularly in surface waters, bacteria of all kinds may be found; those that are harmless, those that are more or less dangerous according to circumstances, and those that are associated with human disease—due either to a more or less constant pollution by residents of the drainage basin or to the potential danger of temporary infection by campers, picnickers, etc. Moreover, changing conditions may suddenly produce temporary contamination of

a dangerous sort which must be overcome quickly and effectively. For such conditions the hypochlorite treatment is primarily applicable."

12. Sewage Disposal and Water Pollution in Relation to Water Supply.

HANSEN, PAUL. *Engineering News*, Vol. 67, p. 839, 1912.

The author sent a list of questions to 120 sanitary officers, engineers, chemists and bacteriologists, asking their conception of the principles that should govern sewage disposal and water pollution in relation to water supply, and now formulates, according to the answers received, what he considers the consensus of opinion on the positive and negative sides of those questions.

13. Methods Employed to Protect the Croton Water Supply from Contamination by the Construction Camps within its Watershed.

PROVOST, A. J. *Journal of the New England Water Works Association*, Vol. 25, p. 301–316, Boston, 1911.

All human discharges are promptly incinerated. Liquid camp waters from laundries and kitchens, are passed through a sand filter and finally treated with chloride of lime, as is all storm water. Each camp has a medical officer on call who examines all applicants for work and vaccinates all those who are accepted.

14. The Pest at Our Gates.

BIGELOW, POULTNEY. *New Broadway Magazine*, 1908. Reprinted by the Merchants' Association of New York, N. Y., 1908, 20 p.

15. Sewage in New York Harbor.

BLACK, WM. M., and PHELPS, E. B. In Massachusetts Institute of Technology, *Sanitary Research, etc., Contributions*, Vol. 7.

Report Concerning the Location of Sewerage Outlets and the Discharge of Sewage in New York Harbor, Submitted to the Board of Estimate and Apportionment, March 23, 1911.

16. Passaic Valley Sewer.

Report on the Discharge of Sewage from the Proposed Passaic Valley Sewer of New Jersey. Metropolitan Sewage Commission, New York, May 23, 1910.

17. Protection of River and Harbor Waters.

WINSLOW, C.-E. A., Am. Mus. of Natural History, *Guide Leaflet*, No. 33, 27p., New York, 1911.

18. Lake Pollution.

McLaughlin, Allan J. Sewage Pollution of Interstate and International Waters, *Hyg. Lab. Bull.*, No. 77, July, Washington, 1911.

Sewage pollution of a water supply shows that the spread of Asiatic cholera, typhoid fever, and other diseases by that supply is possible.

The relation of a sewage-polluted water supply to the typhoid fever death rate is so well known that it seems unnecesary to dwell upon it. The coincident drop in typhoid fever rates with an improvement in the water supply has been observed in hundreds of instances.

The eradication of the "residual" typhoid, or the typhoid which remains after the installation of safe water supplies, depends upon the coöperation of an intelligent public and honest, conscientious physicians with the health officers.

The combating of typhoid fever may be divided into two stages, first, getting rid of the typhoid due to a polluted water supply, and, second, combating the so-called residual or contact typhoid. Many American cities have not even progressed as far as the first stage—that of providing a pure water supply. Many others have provided themselves with a pure water supply, and with smug complacency rest satisfied with the diminished rate if it is below 20 deaths per 100,000.

19. Pollution of Lake Michigan.

Wisner, George M. Report to the Sanitary District of Chicago, 1911, p. 70.

The principal source of danger is from the excursion boats with a large number of passengers. Undoubtedly this condition could be remedied by some federal regulation of shipping, such as using tanks to store the excreta and urine for discharge after the vessels have arrived within the Chicago River. Such handling has been recommended in the west on the watershed of the city of Seattle. The danger from shipping in our case is a live one, since Dr. Young, the Health Commissioner of the City of Chicago, has shown that typhoid fever is far more prevalent on board vessels on the Great Lakes than in the towns bordering on the lakes, and that steamers are not only carriers of passengers and freight, but of typhoid as well. It is deemed very important that no excreta or human waste be dumped into the lake within four or five miles of the shore line.

20. Typhoid Epidemics.

Water Pollution Caused These Severe Typhoid Epidemics. (From "The House Fly," by Howard, L. O.)

The New Haven epidemic in 1901 is instructive. A part of the city is supplied from Dawson Lake on West River, five miles distant. About a mile and a half above the dam a small stream flowed into the river, and about a half mile up this stream was a farmhouse in which occurred several cases of typhoid

fever during January and February. The excreta were thrown into a shallow privy vault 325 feet from the brook and 40 feet above it. Although the lake covered 60 acres and contained 300,000,000 gallons it was quite turbid on March 11. About ten days later the epidemic began in the district supplied by Dawson Lake. During April, May and June 514 cases occurred resulting in 73 deaths.

In the Scranton epidemic, a reservoir containing 1,400,000,000 gallons became infected—1,155 cases of typhoid fever were reported and 111 deaths.

At Plymouth, Pa., the situation was: There were three small reservoirs fed by a mountain stream, along or near which were a very few houses. A man from one of these houses went to Philadelphia and contracted typhoid fever. The dejecta were thrown upon the snow and frozen ground and washed into the upper reservoir when the spring thaw came. The first typhoid case appeared in town on April 9; after April 12 from 50 to 100 cases appeared daily and in one day 200 new cases were reported. Out of 8,000 people 1,104 had the disease and 114 died.

21. Discharge of Sewage into Tidal Waters.

Harpur, W. Paper read before the Royal San. Institute Congress, 1911, *Surveyor*, Vol. 50, p. 200, London, 1911.

The problem is admitting of different solutions under different circumstances. Careful and exhaustive investigation should be made.

1. As whether there is any shell-fish in the locality likely to be contaminated by the sewage.
2. Whether the coast near the outfall was populated or used as a public resort.
3. Whether bathing took place near.
4. As to the height, speed and direction of the tidal currents during a complete cycle, in order to determine whether the sewage would return to the bleach and create a nuisance.
5. To determine from these data
   (a) the time at which the sewage might safely be discharged, and
   (b) the amount of treatment of the sewage, if any, that was necessary.

22. Pollution of Estuaries and Tidal Waters.

Letts, Dr. E. A., and Adeney, Dr. W. E. *Royal Commission on Sewage Disposal Fifth Report*, Appendix VI, London, 1908.

23. The Discharge of Sewage into Tidal Waters.

Soper, George A. *School of Mines Quar.* Vol. 30, p. 239–251, New York, 1909.

24. The Sewerage of Sea Coast Towns.

Adams, H. C. 133 p. New York, 1911.

25. Pollution of New York Bay.

Jackson, D. D. Report to the Merchants' Association of New York, 1909.

Shows that the sewage is not carried away by the tides and "that at many points, sewer outfalls have not been carried below the low-water mark, in consequence of which the solid matters from the sewers have been exposed on the shores." These deposits were found to be covered with flies thus affording ample opportunity for the transmission of typhoid. It was furthermore found that the greater number of typhoid cases were found near the waterfront, and if the curve showing the prevalence of cases was set back two months it coincided with the curve showing the prevalence of house flies. The period of two months represents the time of incubation. The fly curve, of course, also coincides with the temperature curve, but hot weather alone cannot account for the dissemination of the typhoid bacillus.

26. Purification of Water.

Mason, W. P., C.E., M.D. (Professor of Chemistry, Rensselaer Polytechnic Institute, Troy, N. Y.), Chapter 2 and Chapter 4 of Baskerville's "Municipal Chemistry," *loc. cit.*, p. 85.

"Use of Chloride of Lime:—Perhaps the newest method for water purification which we have before us today is the adaptation of something that is decidedly old, viz., the making use of the well-known germicidal powers of 'chloride of lime,' or 'bleaching powder.' It, or a corresponding sodium salt, has been suggested before, but has always been opposed on the ground that it was not advisable to 'disinfect' a water supply. No one took that ground more strongly than I did myself, but we were all entirely unprepared for the discovery that the amount of the chemical required to do excellent work was in reality well-nigh infinitesimal. In short, doses so small as .03 of a grain per gallon, measured as available chlorine, were found to greatly reduce the total count of bacteria and to positively kill all those of objectionable character. In experiments which I conducted myself I found that in waters seeded with pure culture of bacillus coli and also waters to which had been added pollution in the form of human dejecta, there were left no gas forming bacteria of any kind after a short exposure to the small dose of 'bleaching powder' mentioned above. The chemical seems to have a selective action upon intestinal organisms. We are possessed of data dealing with the use of this process upon a large scale, so considerable a city as Jersey City being supplied with water treated by the 'bleaching powder' method. So impressed am I with the excellent results secured by the use of 'chloride of lime' that I think it no rash prophecy to say that a 'bleaching powder' addition will be made to a large percentage of new filter plants, so that during periods of threatening danger, if not during the usual running of the plant, additional safety may be guaranteed. As a notable instance of what this process will do when employed upon a grossly polluted water, let me say that in Chicago I saw the filthy water of 'Bubbly Creek,' containing an average of 700,000 bac-

teria per cc. so improved by the 'bleaching powder' method that the count per cc. fell to 10. Of course, part of this excellent result was due to the sand filter and the dose of alum employed. The bleach is added after the alum and before filtration."

THE TYPHOID SITUATION.

27. The Hygienic Value of Pure Water.

BURDICK, CHARLES B. *Engineering Record*, Vol. 65, p. 286–287, 1912.

It is from the standpoint of health, that pure water brings its largest financial return.

The most important of the water-borne diseases are Asiatic cholera and typhoid fever. The former has been practically eradicated in the most enlightened communities. Great strides have been made in the reduction of the typhoid death rate, but this disease is still prevalent throughout all civilized communities, and very much remains to be done in America. LEIGHTON (M. O.) estimates the average value per life taken by typhoid at $4,035, while $5,000 is very commonly considered to be the value of a life. There are from ten to twenty cases of typhoid for each death. It is very difficult to estimate the cost per case, but statistics available seem to indicate actual expenditures of about 2,200 dollars for each death. HAZEN (Mr. Allen Hazen) has presented figures on five cities where purification works have been introduced that appear to indicate that for each typhoid death saved, three additional lives have been saved from other causes. The pure water has evidently a very beneficial effect upon diseases diarrhœal in nature, and probably also engenders an increased vitality that assists in the resistance to other diseases not water-borne.

After considering all these figures, Whipple concludes that $10,000 per typhoid death saved is a conservative estimate of the saving secured through the purification of polluted supply. Upon this basis a saving of 10 per hundred thousand living is equivalent to $1 per capita per annum (a convenient figure for estimating purposes) and he estimates the value of the purified water at $9.50 per capita per annum at Lawrence, Mass., $4.75 at Albany, N. Y., $3.80 at Binghampton, N. Y., and $4.75 at Watertown, N. Y.

28. Economics of Typhoid.

The following data from a report by FRANK E. WING, *Associate Director of the Pittsburgh Survey*, concern 194 cases of typhoid fever in Pittsburgh, Pa., during the year ending June 30, 1907.

No. of families in which typhoid fever occurred	194
individuals in these families	999
persons taken with typhoid	194
deaths by typhoid	11

No. of children taken with typhoid	89
No. of wage earners	87
Weeks work lost by wage earners	964
Wages lost by wage earners	$10,902
Loss of time by other wage earners, caring for patients, weeks	182
Loss of wages by these caretakers	$1,557
Number of cases treated in hospitals	53
Hospital cost paid by patients	$1,141
Hospital costs paid by charity	$1,534
Doctors' and nurses' bills, medicine, etc., of patients treated at home	$8,179
Funeral expenses of 6 patients who died	$1,032
Total cost	$24,359
Cost of typhoid fever per patient	$125
Cost of typhoid fever per typhoid death	$2,200

29. American Typhoid Fever Losses.

Fisher, Prof. Irving, and Robbins, Miss Emily F. Memorial Relating to the Conservation of Human Life as Contemplated by Bill (S. I.) Providing for a United States Public Health Service. Washington, 1912.

Typhoid fever is estimated by Dr. George M. Kober, dean of the medical department of Georgetown University, to cost over $300,000,000.

Since the discovery of their causes, typhoid deaths and sicknesses have been reduced, but because of the present lack of adequate effort to prevent the remaining losses from the same cause, the number who will succumb to this disease in 1912 exceeds, as pointed out by the Equitable Life Assurance Society, the number killed in six of the greatest battles of the Civil War. This does not count additional sufferers from the malady who do not succumb. It is estimated that the percentage of deaths from this disease in America is three times as great as the percentage in England, Wales, Scotland, Sweden, Switzerland and Norway.

30. Attitude of the Public Towards Sanitary Reform.

McLaughlin, Allan J. *Hygienic Laboratory Bulletin*, No. 83., Washington, 1912.

The difference in attitude towards sanitary measures between the German and the American necessitates a campaign of popular education in America in order to effect that which may be effected in Germany by regulation alone.

This mental attitude of the American citizen towards sanitary regulations must not be considered a disadvantage.

He simply wants demonstration of theories and facts which the German accepts without question, but once the demonstration is made and the American convinced, his is no perfunctory compliance, but he lends his aid with vigor and enthusiasm, which yield prompt and lasting results.

31. Typhoid Death Rates.

Typhoid death rates per 100,000 for all American cities over 100,000, and many European cities during 1910:

Population	City.	Typhoid Death Rate.
240,000	Christiana	2
355,363	Edinburgh	2
595,000	Munich	2
270,109	Hague	2
383,000	Bristol	2
546,882	Dresden	3
455,000	Copenhagen	3
286,000	Newcastle on T.	3
2,260,000	Berlin	4
7,537,000	London	4
570,000	Birmingham	4
248,000	Leicester	4
763,000	Liverpool	4
491,000	Leeds	4
479,000	Sheffield	4
341,000	Stockholm	4
2,130,000	Vienna	4
932,000	Hamburg	5
391,137	Belfast	5
266,000	Nottingham	5
640,000	Rio de Janeiro	5
872,021	Glasgow	6
516,000	Breslau	7
2,775,000	Paris	7
571,000	Amsterdam	7
417,780	Rotterdam	7
508,000	Prague	8
716,000	Manchester, Eng.	9
	Melbourne	9
420,923	Dublin	10
296,000	Bradford	10
280,000	Hull	10
371,000	Turin	12
222,000	Trieste	12
	Sydney	15
1,493,000	Moscow	18
218,000	Portsmouth	18
720,000	Brussels	19
834,000	Budapest	20
183,000	Venice	23
596,528	Milan	35
1,620,000	St. Petersburg	37

Population	City.	Typhoid Death Rate.
102,054	Bridgeport, Conn.	5
125,600	Paterson N. J.	7
104,839	Cambridge, Mass.	9
363,591	Cincinnati, Ohio	9
670,585	Boston, Mass.	11
267,779	Jersey City, N. J.	11
4,766,883	New York, N. Y.	12
347,469	Newark, N. J.	13
2,185,283	Chicago, Ill.	14
218,149	Rochester, N. Y.	14
319,198	Los Angeles, Cal.	14
100,253	Albany, N. Y.	14
237,194	Seattle, Wash.	14
416,912	San Francisco, Cal.	15
687,029	St. Louis, Mo.	15
119,295	Fall River, Mass.	15
150,174	Oakland, Cal.	16
145,986	Worcester, Mass.	16
129,867	Scranton, Pa.	17
1,549,008	Philadelphia, Pa.	17
133,605	New Haven, Conn.	18
181,511	Columbus, Ohio	18
560,663	Cleveland, Ohio	18
224,326	Providence, R. I.	18
214,744	St. Paul, Minn.	19
106,294	Lowell, Mass.	20
423,715	Buffalo, N. Y.	20
116,577	Dayton, Ohio	21
127,628	Richmond, Va.	22
207,214	Portland, Oregon	22
331,069	Washington, D. C.	23
465,766	Detroit, Mich.	23
213,381	Denver, Colo.	27
131,105	Memphis, Tenn.	27
233,650	Indianapolis, Ind.	28
533,905	Pittsburgh, Pa.	28
112,571	Grand Rapids, Mich.	28
137,249	Syracuse, N. Y.	28
339,075	New Orleans, La.	31
223,928	Louisville, Ky.	32
168,497	Toledo, Ohio	37
558,485	Baltimore, Md.	42
104,402	Spokane, Wash.	45
373,857	Milwaukee, Wis.	46
110,364	Nashville, Tenn.	49
132,685	Birmingham, Ala.	49
154,839	Atlanta, Ga.	50
248,381	Kansas City, Mo.	54
301,408	Minneapolis, Minn.	59
124,096	Omaha, Neb.	87

32. The Typhoid Carrier.

Ledingham, Dr. J. C. G. Report on the Enteric Fever "Carrier"; Being a Review of Current Knowledge on This Subject. *Thirty-ninth Annual Report of the Local Government Board of England and Wales*, for 1909–1910, supplement containing the report of the medical officer, p. 246–384, London, 1910.

Upon Koch's recommendation bacteriological stations were established in southwest Germany for the study of typhoid fever, and since many of the reports from these stations have been used by the author in his memoir he gives a brief account of the organization of the German campaign.

The first experimental typhoid station of the German campaign was founded at Trier in 1903 under the directorship of Frosch. Later the number of stations were increased to eleven, located at different places in southwest Germany. The typhoid stations are provincial establishments. Each laboratory has a director, two or three bacteriologists, and several attendants. The workers at each laboratory work in conjunction with the local authorities and have a fourfold duty, as follows:

1. To assist the local physicians in the diagnosis of typhoid fever.
2. To ascertain the source of infection in typhoid cases and render it innocuous, and to seek out infected persons.
3. To watch for unhygienic conditions and to make recommendations concerning them.
4. To make bacteriological examinations of stools and urine in order to determine when convalescents cease eliminating typhoid bacilli.

The workers at these laboratories have added and are still adding a great deal to our recent knowledge on the subject of typhoid fever and the typhoid bacillus carrier.

Brückner examined 316 persons who had had typhoid fever, in previous years and found 3.8 per cent carriers; but if only adults were considered 5.2 per cent.

Aldridge, in India, examined 190 typhoid convalescents in the army and found 3.1% were eliminating typhoid bacilli longer than six months after defervescence.

Tsuzuki examined 51 typhoid convalescents in the Japanese army and found that 5.8% were eliminating typhoid bacilli beyond the three-month limit.

From the statistics from the German campaign, in one series of 3,867 typhoid cases, a carrier percentage of 1 was obtained; in one series of 6,708 cases a chronic carrier percentage of 2.47 and a temporary carrier percentage of 2.15 were obtained.

Several reports are given of attempts to obtain the carrier percentage among the general population where healthy persons only were examined.

Klinger reports on the examination of the excreta of 1,700 persons living in the neighborhood of actual cases, where a carrier percentage of 0.88 was obtained.

Rosenau, Lumsden, and Kastle report on the examination of 1,014 specimens of feces and 26 specimens of urine of persons living in Washington, D. C., where a carrier percentage of 0.3 was obtained; that is, 3 per 1,000.

Minelli examined 250 persons in an institution situated in a town free of typhoid fever and obtained a carrier percentage of 0.4.

33. The Typhoid Bacillus "Carrier," A Review.

Grimm, R. M., Asst. Surgeon, U. S. Public Health and Marine-Hospital Service, *Public Health Reports*, Vol. 26, No. 11, Washington, 1911.

A review of Dr. J. C. G. Ledingham's report on the subject.

34. Typhoid Bacillus Carrier.

BOLDUAN, CHARLES and NOBLE, W. CAREY. A Typhoid Bacillus-Carrier of Forty-Six Years Standing, and a Large Outbreak of Milk-borne Typhoid Fever Traced to This Source: *Jour. Am. Medical Assn.* Vol. 58, p. 7–9, Chicago, 1912.

In this case a dairyman, sixty-one years old, who had had typhoid fever at the age of fifteen, unwittingly disseminated the disease for forty-six years as a carrier: his dairy and home showed to be both exceptionally clean and well kept. However, when suspicion fell upon this dairy or household and accordingly specimens of stool were obtained from the entire household then that of the dairyman developed almost a pure culture of typhoid bacilli on Conrad-Drigalski plates. Subsequent examinations made after a month and again after a year yielded similar results.

The following shows the biologic characteristics of the bacilli isolated from the stools of the dairyman.

Four specimens of feces were examined from this case.

Oct. 23, 1909	showed almost pure culture of typhoid.
Nov. 3, 1909	30% typhoid-like colonies
Dec. 27, 1910	No typhoid-like colonies.
Jan. 27, 1911	50% typhoid-like colonies.

35. Winning Fight Against Typhoid in Army.

TORNEY, GEORGE H. *New York Tribune*, February 11, 1912. Surgeon General Torney, U. S. A., in an article on prevention of typhoid fever by vaccination, comments on the carrier question:

"Permanent human asylums of the typhoid bacillus were once a medical curiosity. 'Typhoid Mary,' as she was called, was discussed in technical publications. Her discovery was as sensational, almost, as the finding of a new continent. Since then we have learned that from 1 to 4% of those persons who have had typhoid fever are chronic carriers of typhoid germs. About three hundred such persons were under observation at one time in southwestern Germany. Eighty-five per cent. of them were women. Most of them had the fever after reaching the middle time of life.

"German physicians say that epidemics of typhoid at insane asylums are often found to have started after the arrival of new patients who are chronic carriers of the bacteria. The bacilli of typhoid are always present in the body wastes of such persons, who, on recovering from the malady, go about their business, handling food. It may be, in markets, stores or hotels, or selling tickets at theatres and railway stations, or paying money out of banks. They are constantly passing their germs along to others, and if the persons so infected are lacking in resistance or defensive bodies in the blood, they are taken down with the disease.

"In Prussia the body wastes of every one who has had typhoid fever and has recovered are examined. Chronic bacillus carriers are thus found, and pre-

cautions are immediately taken. Action of the same kind ought to be the rule in this country."

36. Typhoid Carriers.

HOWARD, L. O. *The House Fly*, p. 128–137, New York, 1911.

Typhoid germs may be discharged from the human system several weeks before diagnosis is possible, continue in numbers six to eight weeks after apparent recovery and exceptional cases may persist during a period of several years. There are authentic records of a patient distributing these germs for seventeen years and being the incipient of thirteen cases during fourteen years of that period. Even the urine of patients may contain active typhoid bacilli.

Kayser, tracing outbreaks to their sources found an outbreak in which seventeen persons were seized (two deaths) was traced to a woman who had no typhoid history but was excreting the specific bacilli. She was employed in the dairy from which the persons seized had obtained their milk. Of 260 cases of typhoid fever investigated, sixty were traced to infected milk.

They had several cases of chronic carriers under observation. A piece of toweling was soaked in a sample of urine which was found to contain 50,000 bacilli per cc. It was then cut into pieces. Pieces kept in the dark were found to be infected with living bacilli up to and including the eleventh day.

In another experiment, one of the carriers voided his excrement in a dry earth latrine, with the result that it was found, that, under the conditions of a dry earth closet and of dry earth methods of disposing of excreta, typhoid bacilli can readily be recovered up to a week. This indicates, say the writers, how easily the infection could be conveyed by flies from such material when left exposed in a latrine pan.

A dairymaid was found at Killworth, England, in 1909, through the investigations which followed a typhoid outbreak.

An epidemic of typhoid in the Tenth German Army Corps in the summer of 1909 was traced to a chronic carrier in the case of a woman who had assisted in the preparation of vegetable salads. She had had typhoid 36 years previously for the only time.

In the same summer there was an epidemic of the fever in Georgetown, D. C., traced to a certain milk dealer.

WATER-BORNE DISEASES.

37. The "Hazen Theorem."

HAZEN, ALLEN, *Trans. Am. Soc. Civ. Eng.*, Vol. 54, Part D, p. 131–154, New York, 1904.

Compares for a number of cities with improved water supplies the typhoid death rates of five years before and five years after said installation of pure water supplies.

He found that not only had these typhoid death rates greatly diminished,

but also, that the general death rates showed a difference of 19% average in the cities of Hamburg (Germany), Lawrence, Mass., Albany, N. Y., Newark, N. J., Jersey City, N. J., and Lowell, Mass.

Hazen attributes the reduction in the typhoid rate to pure water, because in cities similarly situated, without having changed to better water, the typhoid rates had remained stationary.

The general decline of death rates in cities of the latter class (taken from 18 cities for a number of years) amounted to 137 for 100,000.

In comparison with this, in the six cities where the water supply had been radically improved, the general death rate had been reduced by 400 for 100,000.

Of this difference between 440 and 137, 303, only 71 were due to typhoid; the remainder = 232 being deaths due to other causes attributable to improved water supplies.

This important pronouncement by Mr. Hazen, that the reduction in typhoid death rate attributable to improved water supply is accompanied by a much larger reduction in deaths from other causes, has since become known as the "Hazen Theorem."

38. Study on the Hazen Theorem.

Sedgwick, William T., and MacNutt, J. Scott. *Journal of Infectious Diseases*, Vol. 7, p. 489–564, Chicago, 1910.

The results of their studies indicates:

First, That infant mortality is closely related to polluted water.

Second, Closely associated with infant mortality stand diarrhœa and gastro-intestinal disorders.

Third, That a considerable decline in mortality from tuberculosis follows a change from a polluted water supply to a pure water supply.

Fourth, That pneumonia, bronchitis, and other infections are apparently reduced from the same cause.

39. Polluted Water and Infant Mortality.

Fuller, George W., in his "Sewage Disposal," New York, 1912, makes the following comments on p. 110:

"One of the most surprising results of this study is the disclosure of the remarkable relation apparently existing between polluted water and infant mortality. Pure water showed a marked reduction. In a less marked degree this seemed true as regards diarrhœa and gastro-intestinal disorders. As to tuberculosis it is stated that the evidence, though less striking, is interesting and suggestive. The data also seemed to show a marked relation in the decline of pneumonia and bronchitis, following the substitution of pure for impure water."

40. Sewage Pollution and Infant Mortality.

McLaughlin, Allan J. Sewage-Polluted Water Supplies in Relation to Infant Mortality. *Public Health Reports*, Vol. 27, No. 17, 1912. Washington, 1912.

In the *Journal of Infectious Diseases*, August 24, 1910, Sedgwick and MacNutt describe what they call the Mills-Reincke phenomenon. This is a marked decrease in the general death rate of cities independent of the reduction in typhoid-fever deaths following the substitution of a safe for a polluted public water supply. In the same article these writers accentuate the statement of Allen Hazen concerning the relation of a polluted water supply to the general death rate, which is known as Hazen's Theorem. Hazen's statement was as follows:

Where one death from typhoid fever has been avoided by the use of better water, a certain number of deaths, probably two or three, from other cases, have been avoided.

Sedgwick and MacNutt found abundant evidence of the occurrence of the Mills-Reincke phenomenon in studying the statistics of Hamburg, Lawrence, Lowell, Albany and Binghamton. They also found that Hazen's "quantitative expression for the Mills-Reincke phenomenon" when applied to the cities which they studied, was sound and conservative. In their work, Sedgwick and MacNutt brought out the close relation between polluted water and infant mortality. This fact had also been demonstrated by Reincke of Hamburg who laid especial stress on the diarrhœal diseases of children.

From a study of statistics and conditions in cities and towns in the drainage basin of the Great Lakes, the writer is inclined to believe that the reduction in the general death rate, coincident with and following improvement in the water supply independent of typhoid reduction, is largely due to the reduction effected in the group of entities classified as diarrhœa and enteritis.

41. Life of Typhoid Fever Germs in Sea Water.

Fuller, G. W. Sewage Disposal, New York, 1912, p. 140.

Typhoid fever germs will live in unsterilized sea water in gradually decreasing numbers, for periods ranging at least from one week to one month, depending on local conditions.

Observer.	Date.	Days after infection when germ was last observed.
De Giaxa	1889	9
Foote	1895	17
Klein	1896	21
Burdoni-Uffredizzi and Zenobi	1889(?)	14
Herdman and Boyce	1899	20
Field	1904	10

42. Duration of Life of Typhoid Fever Germs in Live Oysters in Sea Water.

FULLER, G. W. Sewage Disposal, New York 1912, p. 144.

Investigator.	Date.	Period (days).	Remarks.
Foote.............	1895	30	Lived longer in oyster than in water.
Chantemesse	1896	2	
Klein.............	1896	17	No record of period of elimination.
Herdman and Boyce	1899	14	Lived longer in water than in oyster.
Field..............	1904	9	

43. Shell-fish Pollution.

FULLER, GEORGE W. *Report of the State Sewage Commission of New Jersey,* 1905, p. 113–114.

There are those who still believe that polluted shell-fish cut very little figure, generally speaking, as regards the public health. Some of these persons appear to have formulated their views without knowledge as to general experiences or the evidence upon the subject. Others for commercial reasons attempt to minimize the evidence, and class it as a whole with some statements and conclusions which are obviously of questionable accuracy. There has been a substantial harmony in the conclusions reached by all who have investigated the subject carefully.

The evidence already presented leaves no room for reasonable doubt that to a limited degree typhoid fever is transmitted by oysters, clams, and some other shell-fish which become infected in sewage-polluted waters.

In Great Britain during the cholera epidemic in 1849 an outbreak of this disease occurred which was considered due to the consumption of condemned oysters; they were, nevertheless, given to school children.

All the members of a supper party of seven at Truro, England (1897), became ill either from typhoid or gastro-enteritis due to eating oysters taken from a source known to be polluted.

At St. André de Sangonis, France, Dr. Chantemesse reported fourteen cases of typhoid fever, and gastro-enteritis from six families who ate sewage-polluted oysters.

From 1894 to 1902 Dr. Newsholme, Brighton, England, investigated 643 cases of typhoid fever. He found 158 cases directly ascribable to the consumption of oysters from sources subsequently proven to be polluted.

At Manchester, England, from 1897 to 1902, Dr. Niven ascribed 118

cases from a total of 2,664 cases of typhoid to oysters and mussels, and 156 more cases were associated with the consumption of other shell-fish.

The Atlantic City epidemic of typhoid during the summer of 1902 was traceable to oysters and clams "freshened" in sewage-polluted waters.

The investigations of Dr. Soper in 1904 showed that two thirds of 31 cases of typhoid reported at Lawrence, L. I., were traceable to shell-fish taken from polluted sources.

44. Sewage Contamination of Oyster Beds.

STILES, GEORGE W., JR., *Year Book of Dept. of Agriculture for 1910*, p. 371–378, Washington, 1911.

From a public-health point of view the most serious menace to the shell-fish industry today is the promiscuous discharging of sewage into natural bodies of water. Years ago, when present-day cities were villages, there was no apprehension regarding the possibility of danger from the wastes of man.

Unless heroic measures are at once adopted, the problem will continue to grow in magnitude and in the same relative proportion as the increase of population of those cities discharging their wastes into waters coming in contact, directly or indirectly, with shell-fish grounds.

From a sanitary point of view, shell-fish reflect the character of the water in which they are grown. Invariably serious evidence of pollution is found in the case of oysters taken from grounds known to receive the wastes of man's activities.

Evidences of Pollution.

During the three last oyster seasons there have been examined in the bacteriological laboratory of the Bureau of Chemistry more than 1,000 samples of oysters, clams, and water taken from representative shell-fish layings along the Atlantic and Gulf coasts. The following tabulated data illustrate how the results obtained indicate the purity or pollution of the samples and show the confirmation of the bacteriological findings by the sanitary inspection:

Bacteriological findings on shell-fish, showing confirmation of results by inspection.

Number and kind of sample.	Organisms per cubic centimeter (Plain agar for three days). At 25°C.	At 37°C.	Gas-forming organisms in ox bile.	Results of bacteriological examination and sanitary inspection.
Oysters:				
No. 1	3,800	410	1 oyster out of 5 showed gas in 1 cc.	Judged to be good; inspection satisfactory.
No. 2	10,500	4,400	2 out of 5 in 1 cc.	Do.
No. 3	10,000	1,900	1 out of 5 in 1 cc. and in 0.1 cc.	Do.
No. 4	1,000	470	5 out of 5 showed gas in 1 cc. and in 0.1 cc.; 2 in 0.01 cc.	Condemned; inspection showed very insanitary conditions.
No. 5	75,000	20,000	9 out of 9 in 1 cc.; 8 in 0.1 cc.; 4 in 0.01 cc.	Do.
No. 6	200,000	40,000	10 out of 10 in 1 cc., in 0.1 cc., and in 0.01 cc.	Do.
Clams:				
No. 7	12,000	1,000	2 clams out of 5 showed gas in 1 cc.; 1 in 0.1 cc.	Judged to be good; inspection satisfactory.
No. 8	30,000	19,000	5 out of 5 showed gas in 1 cc.; 4 in 0.1 cc.	Condemned; inspection showed probable pollution.

45. Bacteriological Examination of Oysters.

HOUSTON, A. C. The Bacteriological Examination of Oysters and Estuarial Waters. *Journal of Hygiene*, Vol. 4, p. 173–200, Cambridge, Eng., 1904.

46. Sewage and Oysters.

RIDEAL, S. The Sterilization of Effluents, with Special Reference to Oysters etc. *Journal Roy. San. Inst.* Vol. 26, p. 378–416, London, 1905.

47. Shell-fish Examination.

JOHNSTONE, JAMES. Routine Methods of Shell-fish Examination with Reference to Sewage Pollution. *Journal of Hygiene*, Vol. 9, p. 412–440, Cambridge, Eng., 1909.

48. Shell-fish Contamination.

STILES, GEORGE WHITFIELD Jr. Shell-fish Contamination from Sewage, Polluted Waters and from other Sources: U. S. Dept. of Agr., *Bur. of Chem. Bull.* No. 136, Washington, 1911. p. 53.

49. The Sanitary Regulation of the Oyster Industry.

Gorham, Frederic P., *American Journal of Public Health*, Vol. 2, p. 77–84, New York, 1912.

50. Economics of the Oyster Industry.

Value of the Oyster Industry in the United States. *U. S. Census Publication*, July 27, 1911.

In 1908, of all fishery products, totalled in value to	$54,031,000
Oysters amounted to	15,713,000 = 29%
Clams amounted to	1,896,000 = 4%
Crabs amounted to	912,000 = 2%
Mussels, etc., amounted to	692,000 = 1%

Production of Oysters by States.

Alabama	$173,000
California	337,000
Connecticut	2,583,000
Delaware	169,000
Florida	269,000
Georgia	339,000
Louisiana	763,000
Maryland	2,228,000
Massachusetts	218,000
Mississippi	295,000
New Jersey	1,369,000
New York	2,553,000
North Carolina	236,000
Oregon	4,200
Pennsylvania	176,000
Rhode Island	969,000
South Carolina	137,000
Texas	168,000
Virginia	2,348,000
Washington	352,000

51. Inspection of Oyster Grounds.

Fuller, C. A., Ph.D. The Sanitary Inspection of Oyster Grounds in the United States. *Jour. Am. Med. Assn.*, Vol. 56, p. 733–736, Chicago, 1911.

The author summarises the work in progress on the protection of shell-fish: Massachusetts and Virginia have been most active and apparently have the problem well in hand.

New York does not feel it has done sufficient work to proceed to fixing of definite standards.

New Jersey is taking active measures for hygienic control of its large shell-fish areas.

In Rhode Island, a shell-fish commission has finished a comprehensive survey of the matters of the state.

Connecticut is about commencing a similar survey.

In Maryland the Health Department is examining bacteriologically various samples of marked oysters, but has formulated no standards of pollution.

The U. S. Bureau of Chemistry, which has in charge the bacteriological examination of oysters and other shell-fish for pollution under the Food and Drugs Acts, 1909–1910, condemns all oysters in the shell which "show the B. coli types of organisms when present in three out of five oysters in 0.1 cubic centimeter of the shell liquor." The government has prevented the shipment and sale of several lots of these oysters which have not come up to this standard.

In Rhode Island, the state shell-fish commission has adopted the above federal standard and refused certificates of inspection to more than one half of the oyster-grounds of the state, comprising an area of over 3,000 acres of cultivated oyster grounds. About 25% of the beds were passed conditionally, subject to later inspection.

The federal standard is a tentative one, and the general opinion of the American Public Health Association seems to be that it is too high.

THE BACTERIOLOGY OF WATER; ITS PRESENT POSITION.

52. The Bacteriology of Water.

FRANKLAND, PERCY F. *Jour. Soc. Chem. Ind.* Vol. 30, No. 6, 1911.

Professor Frankland says in conclusion of his masterful exposition of the subject;

"The all important questions which the water-examiner has to answer are the same today as they have been all along: (a) has the water been contaminated with the excreta of man? and (b) if such contamination has taken place has the water in its subsequent history been subjected to conditions which would insure the destruction or removal of the pathogenic bacteria which may at any time be present in such human refuse.

"To the first of these questions, bacteriology cannot give a categorical answer even today, because we are not acquainted with any microbes which are absolutely characteristic of human excreta. The greatly increased facilities for the detection and quantitative determination of the B. coli, however, have undoubtedly placed us in a position to readily ascertain whether and to what extent a water has been contaminated with excremental matter, irrespectively of whether the latter is of human or animal origin, but it is obvious that this will not in general carry us very far, inasmuch as practically all surface water *must* be more or less so contaminated.

"To the second question a similarly qualified answer again can be readily given. If the water is free from B. coli in a large volume it may safely be concluded that it is free from typhosus in a similar volume. But should the B.

coli be found in a small volume it does not follow that the water may at any time be liable to contain typhoid bacilli, because the discovery of the B. coli does not prove that the water has been contaminated by man at all.

53. Microörganisms in Water.

Frankland, P. F. and Frankland, Mrs. G. C. Microörganisms in Water: Their Significance, Identification and Removal. London, 1894, 532 p.

54. Examination of Water and Sewage.

Standard Methods for the Examination of Water and Sewage. American Public Health Association, New York, 1912, 144 p.

BACTERIAL EFFICIENCY OF HYPOCHLORITE TREATMENT.

55. Effect of Chloride of Lime on B. typhosus and B. coli.

Phelps, E. B. *Water Supply Paper*, No. 229, U. S. Geological Survey, Washington, 1909.

By complete tests the fact was established that typhoid germs are acted upon by this disinfectant in practically the same way as are the B. coli. There was no practical difference. And so, through this chain of evidence it is my opinion that either the ordinary bacterial count of the B. coli results will furnish a satisfactory indication of what will happen to the typhoid bacteria if any are present.

Our ordinary bacterial counts and B. coli determinations are employed not because they have any direct bearing upon the general problem of disinfection, but merely because they are indicative of the results upon the less readily detectable pathogens.

Under laboratory condition in bottles, the relative effect of bleaching powder in various concentrations and for various periods of time upon both typhoid and coli organisms was carefully determined in a series of parallel experiments. The results were practically identical. The effect of hypochlorite upon the two kinds of bacetria is the same. In general the B. coli results parallel the total counts at room and at body temperature, so that either may be employed. It is quite possible, however, that certain waters may contain an unusual percentage of body temperature spore formers, in which case it would be obviously unfair to use the results of the body temperature counts as an index of the efficiency of the process.

56. Comparative Resistance of Bacteria to Chloride of Lime.

Lederer, A. and Bachmann, F., in paper read before the Illinois Water Supply Assn., *Engineering Record*, Vol. 65, p. 360–362, 1912.

Percentage reduction, 15 minutes contact.

(B. typhosus has been omitted from this list.)

Available Chlorine per 1,000,000 water.	B. cloacæ 160,000 in 1 cc.	B. fasc. alcalig. 9500 in 1 cc.	B. paratyph. 3000 in 1 cc.	Prot. mirabilis 8000 in 1 cc.
0.1	......	99.98	......	27.3
0.2	99.69	99.99	99.97	45.5
0.3	99.75	100.00	100.00	63.7
0.5	100.00	......	......	72.7
0.7	......	......	......	63.7
1.0	......	......	......	63.7
3.0	......	......	......	90.9
5.0	......	......	......	90.9

	B. enteritidis. 180,000 in 1 cc.	B. lactis aerog. 180,000 in 1 cc.	B. cholersuis. 500 in 1 cc.
0.1	......	......	.....
0.2	99.83	99.17	95.8
0.3	99.98	99.98	100.0
0.5	100.00	100.00	.....

These results confirm that members of the important group of intestinal bacteria succumb to the minute doses of chloride of lime usually employed in water sterilisation, with the exception of B. mirabilis, suggesting the presence of spores.

In tests made with B. pyocyaneus and sarclutea 0.3 parts per million available chlorine eliminated both species. Ninety-nine and six-tenths per cent. reduction of B. coli was obtained after five minutes' contact with 0.3 available chlorine. The difficulty of eliminating the spores of B. subtilis is borne out by the fact that 400 parts available chlorine per million water only killed 95% in fifteen minutes' contact.

Spores of anthrax were nearly eliminated by 50 parts and completely so by 100 parts available chlorine per million water in fifteen minutes' contact.

57. Bacterial Cells and Chloride of Lime.

Hyde, Charles G., in paper presented to the League of California Municipalities. October 26, 1911.

"All vegetative bacterial cells succumb readily to the action of this oxidizing agent. The spore forms, however, encased as they are with heavy protecting walls which frequently render them capable of successfully withstanding continued boiling, are not destroyed by such quantities of hypochlorite as it would seem rational to apply to water supplies. Fortunately, the bacteria of the intestinal tract, including the normal inhabitants thereof, such as B. coli, and such pathogenic forms as the bacteria of typhoid fever, cholera, etc., are not spore formers and are therefore not able to resist the action of the hypochlorite when applied in sufficient amounts. In so far as the non-spore formers are readily destroyed, it may be said that the germicidal action of hypochlorites is selective and especially destructive of the dangerous species."

58. Resistance of Bacteria to Calcium Hypochlorite.

Wesbrook, F. F., Whittaker, H. A. and Mohler, B. M. *Jour. Am. Pub. Health Assn.* Vol. 1, p. 123–133, Urbana, Ill., 1911.

This paper refers to the treatment in pure cultures of a resistant spore-former isolated from the Mississippi River water. The resistance may be an important factor in the failure to produce complete sterility, and may have caused later rise in bacterial count in certain of the experiments.

The results support the theorem according to which presence or absence of colon bacillus in potable water is considered as a typhoid index.

59. Influence of Temperature on Rate of Disinfection.

Lederer, A. and Bachmann, Frank, in paper read before the Illinois Water Supply Assn., *Engineering Record*, Vol. 65, p. 360–362, 1912.

J. W. Ellms demonstrated, on disinfecting Ohio River water with a hypochlorite solution containing 0.2 parts per million available chlorine, that a lower temperature retarded the rate of disinfection. (Temperatures were ranging from 38° to 89° F.)

Trials with Lake Michigan water, artificially contaminated with B. coli and B. acidi lactici were brought to a temperature of 32° and 50° and 69° F., and then treated with 0.2 and 0.3 parts per million available chlorine. Samples were placed out on litmus-lactose-agar after five minutes, fifteen minutes, thirty minutes and one hour, and no systematic increase in the number of bacteria could be recorded.

Inasmuch as Phelps has shown that disinfection of sewage-filter effluents is influenced more distinctly by temperature changes when effluents are deaërated, it is fair to assume that the very stable lake water, averaging maximum temperature 68° F. may not behave like a more deaërated river water.

60. Bacterial Efficiency of Chloride of Lime.

Studies at the Lawrence Experimental Station, *42d Ann. Report of the Mass. State Board of Health*, 1910, p. 278.

For the purpose of comparison, filter No. 336 was operated during one day in each week without the addition of the disinfectant. The average number of bacteria in the effluent of the coagulation and settling basin on the days when no disinfectant was added was 530 per cubic centimeter, and the average number in the effluent from the filter was 95 per cubic centimeter, the bacterial efficiency of the settling tank being about 93%, the efficiency of the filter being about 82 %, and the efficiency of the system being about 98.3%. The average number of bacteria in the effluent from the settling basin during the remainder of the time, when disinfectant was being added, was 22 per cubic centimeter, and the number in the filter effluent was 13 per cubic centimeter, the average bacterial efficiency of the process of coagulation and sedimentation combined with disinfection being 99.6%.

61. Bacterial Efficiency of Hypochlorite Treatment.

Hoover, Charles P. *Engineering Record*, Vol. 65, No. 16, 1912.

In the author's opinion, absence of gas in the lactose bile, together with low plate counts, now interpreted as indicating a water good bacterially when incubated immediately after collection, are unreliable criteria.

Low counts are found on plates poured immediately after the sample of water was collected.

High counts are found when water had stood for 24 or 48 hours before pouring on plates. Higher counts also develop with longer incubations (72 hours).

Lactose bile fermenting organisms, are sometimes attenuated by the disinfection process; these may be revivified by incubating in a broth solution. The writer describes the course followed in his laboratory to guard against mere attenuation instead of practically complete sterilization of intestinal bacteria, and gives a classification of lactose bile fermenting bacteria.

	B. Coli communis.	B. Acidi Lactici.	B. Coli Group.
Gas in lactose bile	+	+	+
Gas in saccharose broth	0	0	+
Production of Indol	+	+	a*
Reduction of nitrate	+	+	a*
Gas in dulcite	+	0	a*

a* = no further tests made.

62. Bacterial Efficiency of Chloride of Lime.

Cross, Walter M. *Proceedings Illinois Water Supply Association*, March 5–6, 1912.

Germs in 1 cc. of water at Kansas City.

	Before treatment.		After treatment with hypochlorite.	
1911 March	Quindaro River.	Clear Water Basin.	Hydrant at City Hall.	B. coli.
20	10,000	1,200	75	0
21	8,000	1,800	70	0
23	4,000	800	100	0
24	10,000	500	55	0
25	8,000	600	90	0
27	8,000	400	25	0
28	5,000	200	20	0

In 1911 the hypochlorite process was used throughout the year and the number of deaths from typhoid fever fell to 61, against 107 in 1910 when no specific attempt was made to destroy pathogenic germs in the water supply.

63. German Criticism.

Race, Joseph. German Criticism of Water Sterilization with Chloride of Lime. *Journal Soc. Chem. Ind.*, Vol. 31, p. 611–616, 1912.

"Many German sanitarians have not the high opinion of the process that prevails elsewhere, and generally regard it as inefficient. They severely criticise the bacteriological methods of the workers using gelatin plates for determining the efficiency, and give preference to enrichment methods.

"A study of their methods of applying chlorine to water shows that instead of using small quantities of disinfectant and allowing prolonged contact, they have employed as much as 40 parts per million of available chlorine with ten minutes' contact, the excess being then removed by reducing agents, usually sulphites. Even with these large amounts, typhoid and cholera germs were not invariably destroyed, as in many cases the bacilli could be found after treatment, by means of enrichment in broth. Unless the view be taken that one single bacillus is sufficient to create infection in a susceptible individual, the criticisms of the German workers are not well founded, and their methods must be regarded as too stringent. The decreased typhoid death-rate in Toronto and other cities subsequent to the use of hypochlorite treatment is conclusive proof of the efficiency of the process, and refutes the theories of our German confrères."

64. Bleaching Powder as an Agent in the Purification of Water.

Hill, Nicolas S., Jr. *Engineering Record*, Vol. 63, p. 491–494, 1911.

Mr. Hill discusses the sterilization problem from the broader viewpoint of all the etiological factors and says:

"The complexity of the problem of estimating the result of treating a raw water with hypochlorite of lime increases directly in proportion to the number of varieties of the organisms present. It is remarkable, therefore, that more time and attention has not been given to the treatment of water artificially infected with a pure culture of a given bacteria, and to study in this way a number of different varieties and strains. Until this is done in a thorough and satisfactory way the true value of hypochlorite of lime as a sterilizing agent cannot be perfectly demonstrated."

EFFICIENCY OF CHLORIDE OF LIME REPORTED FROM AMERICAN WATER WORKS.

65. Efficiency of Chloride of Lime at Albany, N. Y.

Engineering Record, Vol. 65, p. 697–698, 1912.

Commencing on November 19, 1910, and continuing throughout the year, hypochlorite of lime has been applied to the effluent of the slow sand filters. The average application has been 0.35 part per million of available chlorine (8 lbs. chloride of lime per million gallons).

This treatment was used as a safety factor during the cold months, and was continued during the summer, in order to determine whether by such treatment the number of cases of typhoid fever and diarrhœal diseases could be diminished.

With the help of sterilization the average removal of bacteria, gelatin count, between the influent to the slow sand filters and the pure well has been 99%.

The average number of bacteria sent to the city for the year was 39 per cubic centimeter, with a maximum average for November, when hypochlorite was used but half the month, of 183 per cubic centimeter, and a minimum average in the month of August of 4 per cubic centimeter.

66. Hypochlorite of Lime Treatment Plant at Erie, Pa.

Jennings, C. A. *Engineering Record*, Vol. 64, p. 100, 1911.

Since the installation of the hypochlorite of lime treatment on March 15 the plant has operated continuously. The treatment has varied from 7 to 10 lbs. of hypochlorite of lime per million gallons of water treated or an average of 0.32 parts per million of available chlorine. All of the data have been excellent. It is very gratifying to know that since the inauguration of the treatment not a single sample of the treated water has shown the presence of B. coli. The bacteriological data for the period from March 15 to April 25 follows:

Bacteria per Cubic Centimeter

Water.	Raw.	Treated.
Average	234	6.6
Minimum	84	0.0
Maximum	720	49.0
Character of Samples.		
Samples showing B. coli	7	..
Samples without B. coli	31	76

67. The New Sterilization Plant at Kansas City, Mo.

LOWTHER, BURTON. *Engineering Record,* Vol. 65, p. 555–556, 1912.

The temporary hypochlorite plant installed under stress of typhoid apprehensions in October, 1910, has now been succeeded by a complete up-to-date sterilization plant, housed in a fine building.

Thirty million gallons water are treated daily at the cost of 27.6 cents per 1,000,000 gallons.

Typhoid.	Cases.	Deaths.
In year before treatment	2,000	107
In year after treatment	800	61

68. Results at Toronto, Ont.

RACE, JOSEPH. *Jour. Soc. Chem. Ind.,* Vol. 31, p. 611–616, 1912.

Efficiency of Chloride of Lime with Raw Lake Ontario Water at Toronto Island.

	Bacteria per cc.		Amount per 1,000,000 gals.
1911	Raw.	Treated.	
July	864	27	5 lbs.
August	1,018	12	5 lbs.
September	725	28	8 lbs.
October	1,256	15	12 lbs.
November	6,098	4	12 lbs.

69. Efficiency at Harrisburg, Pa.

At Harrisburg, Pa., where the process has been employed since August, 1909, in connection with the coagulated subsidence and rapid sand filtration, the results have been everything that could be desired. The plant has always been notable because of the very high efficiency which has been maintained in its operation. But since the introduction of hypochlorite as a part of the purification process, the results have been most extraordinary. For example, during the year 1910, Caird (1911) has shown that the bacteria in the effluent of the plant have ranged as follows:

0–5 per cc. during 272 days.
6–10 per cc. during 64 days.
11–20 per cc. during 19 days.
21–30 per cc. during 9 days.
and 31–34 per cc. during 1 day.

At no time during the year was the number of bacteria in the effluent of the plant over 34 per cc. and for 336 days, or 92% of the time, the numbers were below 10 per cc. The average count for the year was 5 per cc. The average number of bacteria in the raw water was 7,800 per cc. Average of 9 lbs. chloride of lime per million gallons.

70. Use of Chloride of Lime at Poughkeepsie, N. Y.

Harding, R. J., Superintendent of Public Works, (*Engineering Record*, Vol. 63, p. 277, 1911), reports that there is absolutely no taste in water. Sterilization with chloride of lime required on the average 0.51 parts per million of available chlorine. The per cent. removal of bacteria for the entire plant is given as 99.8.

71. Jersey City, N. J.

Leal, J. L. *Engineering Record*, Vol. 59, p. 771, 1909.

During a period of 62 days, while 455 samples were taken, only in one case a B. coli was found. Average 7½ lbs. chloride of lime per million gallons.

72. Providence, R. I.

Clapp, Otis F. *Engineering Record*, Vol. 64, p. 516, 1911.

The river water during the year contained from 1,060 to 7,000 bacteria per cubic centimeter, based upon the monthly averages. In the filtered water the average bacterial content was 41, giving a percentage removal of 98.3.

73. Kansas City, Mo.

Engineering News, Vol. 67, p. 779, 1912.

Germs in 1 cc. of water at Kansas City.

March.	Before Treatment.		After Treatment.	
	Quindaro River.	Clear Water Basin.	Hydrant at City Hall.	B. coli.
20	10,000	1,200	75	0
21	8,000	1,800	70	0
23	4,000	800	100	0
24	10,000	500	55	0
25	8,000	600	90	0
27	8,000	400	25	0
28	5,000	260	20	0

74. Treatment of Turbid Water Supplies with Chloride of Lime.

Bartow, E. *Proceedings, Eighth International Congress of Applied Chemistry*, Vol. XVI, p. 7, New York, 1912.

Professor Bartow gave two typical instances of the peculiar action of chloride of lime with turbid waters.

In one case the chemical had been added after some 24 hours' sedimentation, which had reduced the bacteria by 65%. The chloride of lime enhanced the

bacterial removal to 99.1% and subsequent filtration increased the reduction to 99.8%.

The other case refers to coagulation with 1½ hours' sedimentation and subsequent sterilization. The total reduction of 99.9%, however, fell to 93.9% on six days when chloride of lime had been omitted. Then when the use of hypochlorite was resumed, fully 99.9% were again removed.

UNSAFETY OF FILTERS.

75. The Passage of Pathogenic Bacteria Through Sand-Filters.

HERING, RUDOLPH. *Engineering Record*, Vol. 61, p. 595–596, 1910.

A discussion with review and bibliography. No chances should be taken in the water supply of a community. Discussion of possible passage of disease germs through sand-filters, or their propagation within the filters is coupled with the statement that a hypochlorite treatment efficiently and very economically destroys pathogenic bacteria before or after the water is passed through the filter.

76. The Passage of Pathogenic Bacteria Through Sand-Filters.

HERING, RUDOLPH. *Engineering News*, Vol. 63, p. 500–501, 1910.

77. Permeability of Slow Sand-Filters.

BEASLEY, E. B. Investigation of the Permeability of Slow Sand-Filters by B. typhosus. *Jour. of Med. Research*, Vol. 25, p. 101–116, Boston, 1911.

78. Depth to Which Bacteria Penetrate Filters.

Engineering Record, Vol. 65, p. 684, 1912.

At Albany it has become the practice to eject each scraping to an outside storage pile, and then to replace the cleaned sand at definite intervals. From the sand analyses, made by George E. Willcomb, chemist in charge, it has been shown that most of the silt and bacteria penetrate to a limiting depth of 10 inches, consequently before any new sand is replaced the old 10-inch surface is completely renovated and washed by ejection and separation, and then the fresh sand is added on top.

FILTER EFFICIENCY INCREASED BY USING CHLORIDE OF LIME.

79. Increased Efficiency and Reduced Cost.

CAIRD, JAMES. Increased Efficiency of Filters and Reducing Cost for Chemicals by the Use of Chloride of Lime. *Municipal Journal*, Vol. 28, p. 264–265, 1910.

That chloride of lime is of great value in connection with the operation of slow and rapid sand filters is a well established fact. Its use in connection

with slow sand filters will permit of a more rapid rate of filtration without reducing the bacterial efficiency. Chloride of lime will prove of great value in connection with the operation of rapid filtration systems in maintaining the bacterial efficiency and reducing the operating cost. Its proper use will result in less cost for coagulants, a saving in water required for washing filters and a higher bacterial efficiency.

80. Disinfection a Valuable Adjunct to Overloaded Filters.

PHELPS, E. B. *Proceedings Engineers' Club,* Philadelphia, Vol. 27, No. 2, April, 1910.

Disinfection will be found a valuable adjunct to overloaded mechanical filters. The limiting rates of operation on slow sand filters are determined largely by the organic content of the water and by consequent economy in the expensive cleaning processes. The limiting rates on mechanical filters, on the contrary, are practically determined by the necessity for obtaining bacterial purification. Therefore it is especially with reference to his latter type that disinfection will be found important.

81. Results at Baltimore.

WALDEN, A. E. and POWELL, S. T. Results of Investigations by the Baltimore County Water and Electrical Co., with Ozone and Hypochlorite of Lime. *Engineering Record,* Vol. 61, p. 621–622, 1910.

By the use of a very small amount of hypochlorite, averaging 0.087 grain per gallon, it was possible to reduce the alum from 0.87 to 0.58 grain per gallon.

The percentage of water used in washing the filters was reduced from 4.1% to 2.9% at the same time increasing the length of time between changing the filters one hour and ten minutes. The reduction in coagulant of 0.22 of a grain per gallon amounts to 31 lbs. per 1,000,000 gallons; with the cost of alum at 1.3 cents per pound f. o. b. Avalon, the saving was 41 cents per million. Deducting from this amount 11 cents for the amount of hypochlorite used, leaves a net saving in cost of coagulant of 30 cents per 1,000,000 gallons. The actual saving in the operating expenses really amounts to much more, as to this must be added the saving in wash water and the increased amount of water passing through the filter between cleaning.

82. Disinfection of Water in Conjunction with Coagulation.

Forty-First Annual Report of the State Board of Health of Massachusetts, Boston, 1910.

The use of smaller amounts of coagulant during the period of combined disinfection and coagulation resulted in an increase of nearly 25 % in the quantity of water passed through the filter between washings and also in a material reduction on the cost of chemicals, which averaged about $2.62 per million gallons for combined disinfection and coagulation as against $4.86 for coagulation alone. The experiments were with Merrimac River water at Lawrence.

83. Reduction of Clogging.

HYDE, CHARLES G., from paper presented to the League of California Municipalities, October 26, 1911.

"The clogging of filter surfaces may be reduced, when the hypochlorite solution is applied in advance of filtration, thereby lengthening the runs and reducing the amounts of wash water and the labor cost of cleaning surfaces."

84. Increase in Capacity.

JOHNSON, GEORGE A. An Increase in the Capacity of the Pittsburgh Water Filtration Plant. *Engineering News*, Vol. 64, p. 136, 1910.

85. Increased Filter Capacity at Pittsburgh.

JOHNSON, GEORGE A. *Engineering Record*, Vol. 64, No. 16, 1911.

The operation of the water purification works at Pittsburgh has been under the direction of Mr. George A. Johnson of New York for two years and in a recent report he discusses a number of features of filter operation. The recent investigations convince Mr. Johnson that it is possible to obtain 200,000,000 gallons of satisfactory filtered water daily from the fifty-six filters. He proposes to use hypochlorite of lime continuously and to resume the normal rate of filtration, when necessary, within 10 hours after cleaning.

Starting Filters at Full Rate.—It has been the custom, when necessary, to start a filter following a cleaning at a rate of 250,000 gallons per acre daily, increasing this rate every hour at the rate of 250,000 gallons until the desired normal rate is obtained. With beds which have been merely scraped and to which sand has not been restored, this practice has been in vogue since July 25, 1910. Restored beds have uniformly been started at a rate of 250,000 gallons and that rate maintained for one week, after which time the rate has been increased as just noted.

When hypochlorite of lime is used, restored beds, so far as bacterial efficiency and appearance of the effluent are concerned, may be started quickly, as in the case of beds which have been merely scraped. Without the use of hypochlorite such a practice would probably not be wise.

86. The Use of Coagulants with Slow Sand Filtration.

Engineering Record, Vol. 64, p. 476, 1911.

87. Troubles in Filtration Through Algæ.

ELLMS, JOSEPH W. *Engineering Record*, Vol. 63, p. 388–389, 1911.

Conclusions are summarized as follows:

(1) The growth of microscopic plants in the water in the river and in the settling reservoirs during the summer months is coincident with reduced periods of service of the filters.

(2) This reduction in the length of the filtering period occurs intermittently coming on suddenly and oftentimes departing as suddenly.

(3) The trouble is not apparently the result of a rapid increase in the number of organisms passing to the filters, but may be indirectly related to the rise and fall of the number present in the river and settling reservoirs.

(4) It seems more probable that the clogged condition of the sand is brought about by an influx of colloidal organic matter from the settling reservoirs and coagulation basins. The origin of this material may be from the secretions of living microscopic plants and animals, or from bacterial decomposition of this organic matter, or from both of these sources.

(5) The sudden appearance of this phenomenon may arise from a disturbance of the currents and water strata in the settling reservoirs and coagulation basins, produced by an increase in the rate of drawing the water or by the action of the wind.

(6) Bleaching powder by oxidizing the organic matter destroys its colloidal character and thereby cleanses the sand grain, rendering the whole sand bed less resistant to the passage of the water.

(7) The amount of bleaching powder used may be so large, if care is not taken, as to destroy completely the colloidal coating of the sand grain and thereby render the filter sand inefficient as a straining medium.

88. Troubles in Filtration Through Algæ.

Comment on Mr. J. W. Ellms' paper. *Engineering Record,* Vol. 63, p. 388–389, 1911.

At Cincinnati excessive growths of microscopic plant life appeared in the settling reservoirs early in August and Mr. Ellms reports that its continuance during the entire month caused a great deal of trouble in the normal operation of the works. It is not uncommon under such circumstances to use copper sulphate in the raw water, but at Cincinnati a solution of bleaching powder was applied to the coagulated water and was moderately successful in destroying the plant life, although the results were not as satisfactory as had been hoped for. In September the plant life also appeared in the filtered water reservoir and the introduction of bleaching powder at this point was successful in clearing the basin and is believed by Mr. Ellms to be an inexpensive method for maintaining a filtered water reservoir free from troublesome growths. Care must be taken not to use too much $Ca(ClO)_2$ which would impair the straining action by oxidizing the colloid coating of the sand grains.

ODOR, TASTE, INFLUENCE OF TREATED WATER ON HEALTH.

89. Odor and Taste in Water Sterilized by Chloride of Lime.

Race, Joseph. *Jour. Soc. Chem. Ind.*, Vol. 31, p. 611–616, 1912.

When any compound of chlorine is present in amounts exceeding 1 part per million of available chlorine, it can generally be detected by the senses. This is the result of many experiments with Lake Ontario water, and although in

some cases quantities smaller than 1.0 part per million (equal to 25 lbs. of chloride of lime per million gallons) could be detected occasionally, many blanks were also said to contain chlorine, so that many of the positive results were due to auto-suggestion.

The majority of complaints regarding water supplies which are treated with small quantities of chlorine are due to these natural and uncontrollable causes, and although samples are often said to taste of chlorine, it will generally be found that chemical tests give a negative result. As the reaction with potassium iodide and starch in acidified solutions is at least five times as delicate as the palate and nose, these complaints must generally be ascribed to auto-suggestion. In these cases the number of complaints will be found to bear no relation to the amount of disinfectant used: typical examples of this phase of the treatment were met with during the summer season on Toronto Island in 1911. Many complaints were received during the early part of the season when the rate was only 0.20 part per million of chlorine, and these entirely ceased during the latter half of the season when the rate was increased to 150%. The nature of the complaint has been the same as in other places where chlorine is in use; that it caused colic and other human ailments; that cattle and other animals refused to drink it; that it injured plants, fish, and birds, and extracted abnormal amounts of tannin from tea. No reliable evidence was ever produced in support of these statements, and they ought, therefore, to be treated as myths.

90. Hygienic Considerations.

Editorial in *Jour. Am. Med. Assn.*, Vol. 58, p. 279–280, Chicago, 1912.

"On the score of public health no objection whatever can be raised to the addition of hypochlorite to drinking water in the quantities commonly used. No injurious effect on the stomach or any other organ has been traced or can be predicated with any degree of probability. The treatment is wholly harmless.

"A humorous touch is given to the matter by the imaginary grievances that find utterance, such as fancied injury to delicate fabrics, bleaching of the hair and the like. Before the chemical is added complaints that the tap water has an unpleasant taste or smell come from people who have read in the newspapers that the hypochlorite treatment is about to be instituted. It goes without saying that proper care should be exercised in adapting the dosage to the water to be treated and in assuring thorough mixing. The demonstrated advantages of hypochlorite disinfection certainly overbalance all known or fancied disadvantages."

91. Professor Heulett's Testimony in the Jersey City Case.

Johnson, George A. *Journal of the American Public Health Association*, Vol. 1, p. 562–574, Urbana, Ill., 1911.

In the Jersey City case, Prof. G. A. Heulett testified that in his examination of the Jersey City water to which had been added 10 lbs. per million gallons

of bleaching powder, he was unable to determine the presence of free chlorine. It is a fact that there has been no chemical test yet devised which is capable of identifying the presence of free chlorine in an alkaline solution such as water is. Professor Heulett stated, however, giving all possible benefit of the doubt to the plaintiff in the case, that if 10 lbs. of bleaching powder per million gallons were added to the Jersey City water, basing his assumption upon the theory of electrolytic dissociation, it was theoretically possible for there to be present in the water after treatment free chlorine to the extent of 6.4 parts in a trillion parts of water. He admitted that he was unable to prove this assumption. It was, furthermore, pointed out in this case that if Professor Heulett's theory was correct, in order for an adult to obtain a medicinal dose of free chlorine, such as has been administered in cases of typhoid fever as an anti-ferment and germicide, it would be necessary for such a person to drink a gallon of water so treated each day for 7,180 years.

92. Objections of the Uninformed.

HYDE, CHARLES G., Paper presented to the League of California Municipalities, October 26, 1911.

Many people object to having chemicals of any sort applied to their drinking water. While in the opinion of sanitary engineers such views have no merit whatever in the case of coagulants, such as aluminum sulphate properly applied in connection with subsidence and filtration, and in the case of hypochlorites properly applied in connection with the sterilization of water, nevertheless the situation is often controlled by loud protests of such persons.

It may be safely concluded that the treatment of waters with such quantities of hypochlorite as would be required for efficient purification from the bacteriological standpoint, can have no possible deleterious effect upon human beings; on the contrary, the destruction of harmful bacteria and the oxidation of organic matter should be productive of most important hygienic benefits.

The experience with the hypochlorite treatment shows that the amount of chemical applied must be carefully regulated in order that tastes and odors may not be communicated to the water. The action of hypochlorites upon swampy tastes and odors and those produced by certain industrial wastes is stated by Johnson (1911) to be negligible.

93. Odor from Excess of Bleach.

PHELPS, E. B., stated in course of discussion (*Proceedings of the Engineers' Club of Philadelphia*, Vol. 27, p. 150, 1910):

"I may say that the odor is a very serious matter to be dealt with. If we get too much bleach, we get an odor anyway. If there is too much organic matter, we are pretty sure to get the odor if we put in the bleach before it goes to the filter. It is not a chlorine odor; it is what we call a vegetable odor. We get around the difficulty by adding the bleach after filtration, and I think that is, on the whole, the best place to add it."

MODE OF APPLICATION OF CHLORIDE OF LIME IN WATER STERILIZATION.

94. Amount of Hypochlorite Required.

GAGE, S. DEM. Determining in Advance the Amount of Hypochlorite Required for Sterilizing Any Given Water.

Mr. Gage, who is biologist of the Massachusetts State Board of Health made the following statement concerning the difficulty of proportioning the amount of hypochlorite to the varying conditions of the water treated.

At present there is no way of telling how much chlorine is needed, except by the results of bacterial analysis, which requires 18 to 24 hours for body temperature and from 2 to 4 days for the room temperature, which is the one usually made. After a disinfecting plant has been running for some time, if a complete record has been kept of all variations in raw water and the amount of disinfectant required with each, it may be possible to estimate the amount of bleach to use at different times, but there is no chemical test which will indicate with any degree of certainty how much chlorine is going to be absorbed by the water before the destruction of the bacteria occurs.

The oxygen-consumed determination indicates this more closely, perhaps, than any other chemical test. Experiments with many hundred samples of water and sewages at Lawrence, have shown that the amount of bleaching powder required could have been predicted within 10% in about half the samples.

In the rest of the samples the amount required as determined by bacterial tests was anywhere from one-tenth to one hundred times the amount estimated from the oxygen-consumed values.

It may be that some satisfactory method will be devised by which the amount of bleach can be determined in advance. If polluted waters are to be treated by this method without filtration, and the health of the community is to depend on the satisfactory application of this process, some such test is essential, before the element of danger is entirely removed.

95. Preparation of Hypochlorite Solutions.

JOHNSON, GEORGE A., in paper presented before the Milwaukee Convention of the American Public Health Association, 1910.

"It is the more common practice to make up hypochlorite solutions of ½% strength; that is, 1 lb. of the bleaching powder to 200 lbs. of water. It is probable that solutions as strong as 4% or 5% may be mad ewithout material loss of oxidizing power. But the more dilute the solutions the more easy they are to work with because of the deposits of quicklime formed in orifices and in pipes.

"As to material for solution tanks, concrete appears to be the most suitable. Iron tanks may be used, but they are attacked by the chemical and eaten

through eventually, although they last a long time owing to the protection afforded by deposits of lime upon the exposed surfaces. Black iron pipes have lasted for over two years at the Boonton plant, and special bronze pumps have lasted well at a number of places. Wooden tanks are the least suitable of all, but of these cypress seems to be the best material. White pine is reduced to a pulp in a comparatively short space of time."

96. Apparatus for Application.

An Apparatus for Applying Chloride of Lime Solution to Water Flowing in Pipes under Pressure. *Engineering News*, Vol. 65, p. 619, 1911.

The problem has been met by the Simplex Valve and Meter Co. of 112 North Broad Street, Philadelphia, Pa., by utilizing the well-known relationship between pressure drop and rate of flow in a venturi tube.

The feed pipe is connected into the throat of the venturi tube in the main, and by means of suitable connections, the supply of solution is subjected to the pressure main just above the venturi tube. Thus the effective pressure difference forcing the solution through the feed pipe is always proportional to the existing rate of flow through the main.

97. Dosing Apparatus.

Another Venturi-Tube Dosing Apparatus for Water Supplies. *Engineering News*, Vol. 67, p. 981, 1912.

98. Method of Sterilization.

Johnson, George A. Sterilization with Hypochlorite of Lime, Pittsburgh, Pa. *Engineering Record*, Vol. 64, p. 476, 1911.

Experience has shown at Pittsburgh that 3 lbs. of the powder per million gallons of water treated will keep the bacterial content of the filtered water at all times low and virtually free from germs of sewage origin.

It has been the custom to apply the dry powder to the water at the gatehouse as it passes over a weir from the filtered-water conduit into the filtered-water basin. At this point the water strikes against a header wall approximately 25 feet from the end of the filtered-water conduit, and is then deflected at right angles through the filtered-water basin. This arrangement gives an excellent opportunity for thorough mixing of the germicide with the water, which is essential.

99. Hypochlorite Plant in Cleveland, Ohio.

Scholz, C. F. *Engineering News*, Vol. 67, p. 448–449, 1912.

The detailed description of this plant, which serves a water pumpage of 100,000,000 gallons per day, shows first how the 1% solution of chloride of lime is conveniently made by discharging water from a meter into the mixing tank, viz., 35,000 lbs. water per barrel bleach of 350 lbs.

The solution, clarified by five hours settling is fed into the water in the tunnel from orifice tanks. The orifices have brass plates into which rectangular openings a half-inch wide have been cut.

The length of these openings can be varied by means of brass slides equipped with pointers traveling over a brass scale. The orifices were calibrated to read in pounds of solution discharged per minute, by means of a $\frac{5}{8}$-inch water meter in the supply pipe to the orifice ranks. The water level was kept constant and 12 inches above the orifice slide. Assuming the weight of 1 cubic foot of water at 62.4 lbs., the following rates were observed and marked:

20	lbs.	per	min.	= 1	cu.	ft.	in	3	min.	7	sec.
30	"	"	"	= 1	"	"	"	2	"	5	"
40	"	"	"	= 1	"	"	"	1	"	34	"
50	"	"	"	= 1	"	"	"	1	"	15	"
100	"	"	"	= 1	"	"				37.5	"
130	"	"	"	= 1	"	"				29	"

The scales were marked in 10-lb. intervals from 0 to 150 lbs. per minute. Assuming that the strength of the solution be 0.0037 available chlorine and that it is intended to add 0.7 part per million gallons of water pumped, the amount of solution to be added per minute for a pumpage rate of 100,000,000 gallons per day would be .

$$\frac{100{,}000{,}000 \times 8.34 \times 0.0000007}{24 \times 60 \times 0.0037} = 109.6 \text{ lbs.}$$

or 1.096 lbs. per minute per million gallons per day.

100. Method at Montreal, Quebec.

Engineering Record, Vol. 65, p. 260–261, 1912.

In the new plant of the Montreal Water and Power Company the hypochlorite mixing tanks are circular in plan. The mixing will be done mechanically by revolving rakes. The tanks are to be charged by means of cylindrical bottom dump buckets which just fit over an opening in the top of the tank.

The orifices of the constant level orifice tanks are of hard rubber, with micrometer adjusting mechanism.

101. New York City.

Sterilizing the Croton Water Supply. *Engineering Record,* Vol. 65, p. 595–596, 1912.

The combined maximum flow of the two aqueducts is 380,000,000 gallons per day and it was estimated that about 16 lbs. of commercial hypochlorite of lime per million gallons of water would be required. The hypochlorite will be delivered in metal drums weighing from 750 to 800 lbs. each. These will be unloaded at the ground-floor level and handled within the building by an overhead crane with a capacity of 2 tons.

Handling the Chemical.

The drum is picked up by the overhead crane and carried to a pit. The head of the drum is then cut out, the drum revolved on the trunnions, and the contents discharged, as required, into a movable steel hopper with a box at its bottom, provided with a plate-glass front graduated for measuring the chemical. The bottom of the hopper is in the form of an ordinary stove-grate and by turning a crank the grate bars are revolved and break up any lumps of the hypochlorite before it enters the measuring box. The inverted drum and hopper are then picked up by the crane and transferred to a platform above the chemical solution tanks. There are two of these tanks and in the platform over each is an opening a trifle smaller than the base of the measuring box which forms the bottom of the hopper. The hopper and drum are set over this opening and the proper amounts of the chemical, as determined by the gauge-glass in the measuring box, are dumped into the solution tanks by pulling out a slide in the bottom of the measuring box. The latter fits tightly over the opening in the cover of the tank, and with the aid of a canvas hood prevents the escape of fumes.

The Solution Tanks.

The two chemical solution tanks are of reinforced concrete, 10 feet in diameter and about 8½ feet deep. These two tanks are similar in all respects and a connection between them is afforded by a bronze overflow weir in the dividing wall. Below the opening in the cover of each tank is a basket screen made of No. 11 bronze wire (⅜-inch mesh) fastened to a frame-work of angle iron bars. The dry hypochlorite falls from the measuring box directly onto this screen. Below the bottom of the screen is a 3-inch galvanized wrought iron pipe with perforations in its top through which water, under a head of 4½ feet flows from an elevated wooden tank in which the level is kept constant by continuous pumping from the new Croton aqueduct, and by means of an over-flow weir. The rate of flow from this tank is regulated to any amount desired by an indicator valve, graduated in gallons per minute. The vertical jets of water from the perforated portion of the pipe pass up through the bottom of the screen and dissolve the hypochlorite of lime. The level in the main solution tanks is maintained constant at a depth of 6 feet above the bottom by means of the overflow weir in the dividing wall previously noted. The excess solution, therefore, is not wasted but is stored in the tank which happens to be out of service. It is proposed at present to use a 2% solution and to introduce into the Croton water 0.5 part per million of available chlorine.

To insure uniformity in the strength of the solution air under pressure will be blown upward through the liquid from a manifold of 2-inch perforated pipe located upon the bottom of each tank. The air will be supplied by an electrically operated blower in the machinery room. There will be no moving parts such as revolving rakes or other forms of stirring paddles.

Rate of Application.

The rate of application of the solution to the Croton water depends upon two factors, the depth of liquid in the tank and the size of the orifice opening of the outlet. Although the surface level in the main tanks is intended to be constant it is apt to vary slightly, due to the bubbling of the air and the introduction of fresh charges of hypochlorite; a stilling chamber, therefore, is connected to each tank by a 14-inch screened opening at the bottom and it is in the bottom of these stilling chambers that the graduated orifice outlets are located. From these orifice openings the solution flows by gravity through 6-inch salt-glazed, vitrified pipe to the openings in the arches of the new and old Croton aqueducts. Sediment which collects in the tanks is to be removed by 6-inch sludge drains, leading to underground sludge vaults lined with dry rubble walls.

Mixing with Aqueduct Water.

In the case of the old Croton aqueduct, which carries about 80,000,000 gallons of water daily, the hypochlorite solution will be introduced by means of a 2-inch vertical pipe perforated with ten ½-inch holes. A short distance below the point of application two sets of wooden baffle-boards will be placed across the aqueduct section to deflect the water first to the right and then to the left, thereby securing a thorough mixture.

In the case of the new Croton aqueduct, which carries about 300,000,000 gallons daily, a more elaborate scheme of feeding the chemical and mixing it thoroughly with the water is contemplated. Through a man-hole opening in the arch a perforated 3-inch main feed-pipe will extend to the invert and to it there will be connected two sets of horizontal cross-arms each containing openings through which the hypochlorite will escape. By this device the solution will be applied at the sides as well as at the center of the section and a fairly even distribution of the chemical will result. It was realized, however, that the velocity of flow in the aqueduct varies appreciably at different points in the sections, the water at the center flowing faster than at the sides. To destroy this inequality in the rate of flow and to mix the chemical thoroughly with the water a set of deflecting wings was designed to be placed just downstream from the point of application of the chemical. These wings are galvanised wrought iron plates, curved at the end and hinged to a vertical standard so as to form a wedge which cleaves the column of water moving through the aqueduct and tends to throw the divided stream against the sides of the section. This will cause a swirling and eddying of the water and aid greatly, it is thought, in mixing the hypochlorite solution. The spread of the wings may be increased or diminished by a pair of cams, operated by a hand-wheel and worm gearing from the top of the man-hole.

The flow through the new Croton aqueduct is very nearly constant and it is not expected that it will be necessary to make many changes in the rate of application of the hypochlorite of lime after the plant has been in operation.

REGULATION OF FEED.

Readings of the depth of water in the aqueduct, however, will be made from time to time and from these heights the volume of flow is determined with a fair degree of accuracy. In case of any considerable increase or decrease in the amount, the chemical feed will be regulated at the orifice outlet or the strength of solution altered either by varying the charge of hypochlorite of lime or by opening up or throttling the indicator valve which controls the flow of water into the solution tanks.

102. Nashville, Tenn.

REYER, GEORGE. *Engineering Record*, Vol. 64, p. 337, 1911.

By treating Cumberland River water with aluminum sulphate, giving it 1¾ days' storage, adding 0.1 grain per gallon of hypochlorite of lime and finally retaining it 1¾ days longer in the second half of a 51,000,000-gallon storage reservoir, a supply was furnished to Nashville, Tenn., practically free from turbidity.

A hypochlorite of lime plant designed on the same general scheme as the aluminum sulphate plant was installed in August, 1909, at the opposite end of the dividing wall where the water flows over a short weir into the second basin. A 2-horsepower motor drives a jackshaft to which are connected two centrifugal pumps and the paddles in the tank. One of the pumps supplies water to the tank and the other is a circulating pump, with its suction connected to the apex of the cone-shaped bottom of the tank and its discharge near the top of the tank. An overflow pipe carries the solution to a perforated pipe spanning the weir. An attendant applies the required quantity of bleach every 15 minutes. The installation cost is about $400.

103. Hypochlorite Treatment of the Omaha Water Supply.

CRAVEN, JAY. *Engineering Record*, Vol. 63, p. 128–129, 1911.

The sterilizing well is covered by a building 18 x 54 feet in plan, which contains a small laboratory, tanks for mixing and storing the hypochlorite solution, and a chemical storage room.

All lumps are broken up by stirring paddles which are rotated by a 2½-horsepower water-motor until a thick paste is formed; the stirring generally continues for at least two hours. The concentrated solution is run into the reinforced concrete storage tanks on the floor below.

The two tanks are connected with orifice boxes in duplicate. Theoretically, with a 6-inch head, the graduated opening of the orifice should give a definite flow of solution, but in practice it did not do so, because of the deposits in the box, and a caking on the sides of the slot. To overcome this difficulty and keep track of the feed readings are taken each hour on forms prepared for that purpose.

The solution is quite hard on the metal in the boxes, and the floats, although painted and protected as well as possible, have to be replaced every two or three months. Glass floats are to be put in to overcome this.

104. Ottumwa, Iowa.

Engineering Record, Vol. 65, p. 494–495, 1912.

Aluminum sulphate in conjunction with lime is used for coagulation and the bleach quota delivered by gravity to the filtered water as the latter passes over a weir on the way to the detached filtered-water basin.

After the bleach is mixed with water in a closet cast-iron tank with agitator, it is stored in covered concrete solution tanks from which it is fed to the porcelain-lined orifice tanks.

105. Grand Rapids, Mich.

Engineering Record, Vol. 64, p. 379–381, 1911.

With the new plant the hypochlorite will be received in thin sheet-steel drums containing from 750 to 800 lbs. each. The drums will be opened under water, and for this purpose a dissolving tank has been provided with a false bottom consisting of cast-iron grate bars. The drums will be lifted into position by means of a chain block. Sharp steel points will then be driven into the head of the drum by means of a shaft extending through a stuffing box in the side of the tank. This shaft will be forced home by means of a lever on the outside of the tank. A ratchet and pawl will then furnish the means for turning this drum, while a large can opener is provided for cutting it in two, which will be done after the tank has first been flooded with water. There will be three hypochlorite-solution tanks made of reinforced concrete.

Chemical Control.

From the solution tanks the chemicals flow by gravity to the controllers which are located on the floor beneath, and after passing through the controllers they will flow by gravity to the point of application to the water. Duplicate lines are provided for all chemicals and it is the intention to first admit the milk of lime to the water where it enters the mixing chamber. A little later the alum will be added, and it is so arranged that the alum can be applied at different points at short intervals along the center passage. The hypochlorite will be added to the water at the point where it leaves the clear-water basin on its way to the high-lift pumping station.

106. Brainerd, Minn.

Bass, Frederic. *Engineering Record*, Vol. 63, p. 161, 1911.

The amount of chemical necessary for a day's run is placed in the tank, which is filled with water from a tap. The mixer is set in motion and the solution prepared. The storage barrels are then filled, the air cocks in the top being open. When the barrels are filled the air cocks are closed and the valve on the pipe leading to the administering keg is opened, air entering the barrel from a pipe connecting the top of the storage barrel with a keg. The solution flows from the keg (which is open at the top) through an orifice in a vertical tube which extends through a packed opening in the bottom of the keg.

The solution flows into the keg from the barrel and rises in the keg until it covers the open end of the pipe supplying air to the barrel; as soon as this occurs the flow from the barrel is checked until the water level, lowered by the flow from the orifice, falls below the end of the air pipe. As the solution flows into the keg faster than it flows out through the orifice, the open end of the air pipe is again soon covered and the flow from the barrel again checked. A constant level can thus easily be maintained without the use of any moving parts such as are necessary in the ordinary ball-cock apparatus. Ball-cock orifice tanks are sold by filter companies for about $30; this arrangement costs about $1 and its life is longer.

107. Minot, N. D.

Engineering Record, Vol. 64, p. 408–409, 1911.

A rapid filter plant at Minot, N. D., comprising coagulant basin, three 500,-000-gallon filters, chemical-feed apparatus, clear-water reservoir and motor-driven machinery for the filters as well as for the high-duty pumps has been in service over a year.

Hypochlorite of lime solution is made in a wooden tank 3 feet in diameter and 4 feet deep. Small centrifugal pumps located directly over the tanks pump an excess solution to the orifice boxes, where regulation is obtained by manipulating adjustable orifices. From these boxes the chemical solutions flow by gravity to the forebay, where the lime and iron solutions are applied.

108. Toronto, Ont.

Race, Joseph. *Jour. Soc. Chem. Ind.*, Vol. 31, p. 611–616, 1912.

Dosing at Toronto Island is effected by means of a small plunge pump, the piston of which is connected with the piston of the main supply pump. Each stroke of the pump corresponds to a stroke of the small one, which has check valves placed at the inlet and outlet. The amount of chloride of lime is fixed by varying the concentration of the solution.

109. Action of Solutions of Chloride of Lime on Construction Materials.

Stevens, H. C., Asst. Eng., New York Board of Water Supply. *Municipal Journal*, Vol. 30, p. 124, 1911.

Metals standing action of chloride of lime 3-inch galvanized iron pipe; galvanizing not serviceable, attacked after a year of use.

Tin—very well.

Brass orifice plates—very well.

Good grade of brass shows no signs of damage.

Bleaching powder cleans organic matter from pipes of galvanized iron without affecting the metal.

Materials injuriously affected:

Wrought iron piping, 2-inch, rusted through in four months.

Brass pipe, less rapidly than wrought iron.

Brass valve stems only slightly affected.

Twenty gauge copper seriously affected.

Wood readily attacked. Tanks of white pine were showing serious damage within a month.

ADVANTAGES AND LIMITATIONS OF PROCESS.

110. Adaptability and Limitations.

JOHNSON, GEORGE A. Hypochlorite Treatment of Public Water Supplies; its Adaptability and Limitations. *Engineering Record*, Vol. 62, p. 321–323, 1910.

ADVANTAGES OF THE PROCESS.

Reciting the practical status of the use of hypochlorites in connection with the purification of water, it may be stated that the advantages of the process are as follows:—

1. Substantially complete destruction of objectionable bacteria, particularly those of intestinal origin.

2. Reliability and ease of application of the chemical, together with the small variation in the required dose.

3. Total absence of poisonous features either in the chemical product as applied to the water or in any of its resulting decomposition products.

4. Merely nominal cost of the chemical and its application.

5. Speed of reaction, making unnecessary any substantial arrangements as to basins other than storage facilities.

6. Substantial saving in the cost of coagulation of waters that are of sufficiently unsatisfactory appearance to require clarification or filtration.

7. Permitting rates of filtration materially in excess of those possible where high bacterial efficiency is required of the filtration process in the absence of sterilization.

8. Reduced clogging of the filter beds with a consequent lengthening of the runs between cleanings, due to the destruction of various forms of algæ.

LIMITATIONS OF THE PROCESS.

In making a complete analysis of the practicability of this process, it is necessary to recognize the fact that it is not possible by the use of this germicide to accomplish certain features looked for in connection with certain styles of water treatment, as follows:—

1. In ability to remove or destroy all of the spore-forming bacteria, but which kinds of bacteria are not considered to be pathogenic to man; at least those common to water.

2. Inability to remove bacteria which are embedded in particles of suspended matter.

3. Inability to remove turbidity.

4. Inability to remove appreciable amounts of color or dissolved vegetable stain.

5. Inability to remove organic matter appreciably.

6. Inability to remove creosote tastes or odors, coming from the cleaning of stills used in the destructive distillation of wood.

7. Inability to remove swampy tastes or odors.

8. Inability to soften water; as a matter of fact the addition of hypochlorite of lime usually results in a slight increase in the hardness of the water, although this is not ordinarily measurable, notwithstanding the fact that the commercial product usually contains a little free quick-lime which reduces slightly the carbonic acid in the water.

9. Difficulties encountered in applying this process except with the greatest care to waters which contain substantial quantities of reducing agents or compounds capable of oxidation, such as nitrites and unoxidized iron.

EMERGENCY PLANTS.

111. A Portable Plant.

Childs, J. A. and Whittaker, H. A. The Traveling or Portable Hypochlorite Water Disinfecting Plant of the Minnesota State Board of Health. *Engineering News*, Vol. 65, p. 402–403, 1911.

The idea of maintaining a portable hypochlorite plant was first advanced by Mr. H. A. Whittaker. A later design, on which several plants have been constructed, was developed by Mr. J. A. Childs. These plants purpose to be placed at the service of smaller municipalities (25,000 to 1,000,000 gallons daily) in case of need and at the shortest notice. The first plant was used at Baudette in a typhoid epidemic, October 13, 1910.

STERILIZATION IN DAIRIES.

112. Sterilization of Milk Bottles.

Whittaker, H. A. and Mohler, B. M., of the State Board of Health of Minnesota. *Am. Jour. of Public Health*, Vol. 2, p. 282–287, New York, 1912. (A paper commnicated at the Annual Meeting of the American Public Health Association, Havana, Cuba, December, 1911.)

The bacterial count on bottles in eight different dairies visited, showed an average of 120,000 per bottle before treatment. This was determined by rinsing the inside of the bottle with a definite amount of sterile distilled water and immediately plating an aliquot part of the liquid.

The treatment was done in a tub of sufficient size to permit submerging of the bottles in a bleach solution of 3 parts per 100,000 water.

The bacterial counts after treatment averaged 45 per bottle.

SWIMMING POOLS.

113. The Carnegie Swimming Pool at Yale University.

Rettger, L. F., and Markley, Samuel C. *Engineering News*, Vol. 66, p. 636–637, 1911.

Eye and even venereal infections have been alleged to be caused by the swimming pool. Letters of inquiry brought out the fact that most of our large universities and colleges make no provision for purification of water. In some cases the water is filtered at intervals and returned to the pool.

At Purdue University the chloride of lime was thrown over the surface of the water, after which bacteriological tests were made; 20 lbs. bleach used on 1,000,000, gallons water.

At Brown University 12 lbs. bleach per 1,000,000 gallons water used.

The results were most successful at Yale. In a pool of 150,000 gallons capacity 8 to 12 lbs. chloride of lime per million gallons are used daily, or at least every second day.

114. Disinfecting Swimming Pools.

Whipple, M. C. Experiments on the Use of Chloride of Lime for this Purpose. *Municipal Jour.*, Vol. 30, p. 577–578, 1911.

115. Northwestern University.

Lewis, W. Lee. Disinfection of Indoor Swimming Tank, at Northwestern University. *Engineering News*, Vol. 65, p. 689–690, 1911.

From the discussion it would seem that an indoor swimming tank, of the capacity, usage and frequency of filling, represented by that of the Northwestern gynmasium, is a possible menace to the health and well-being of those using it. It is believed that the data submitted establish the wisdom of treating such a tank from two to three times a week, with 1-lb. quantities of chloride of lime. Since the conditions in the Northwestern tank are, without doubt, typical of the average indoor swimming tank, the foregoing statements are believed to be of general applicability.

116. Sanitation of Swimming Pools.

Whipple, M. C. and Bunker, J. W. M. *Municipal Journal*, Vol. 31, p. 526–527, 1912.

It is stated that typhoid fever was contracted in a swimming pool; also diarrhœa. Temperature of 75° F. highly favors bacterial growth.

Results achieved at Brown University, Brooklyn Polytechnic Institute, Northwestern University, and elsewhere, have shown that with chloride of lime in proportion of 0.4–1 available chlorine per million applied at intervals of 1 to 3 days, the treated water can be used several days longer without draining and cleaning the tank saving thereby $9.70 per week.

117. Conditions in Swimming Pool Disinfection.

ROBERTS, DR. NORMAN, Hygienic Laboratory, Washington. *Engineering News*, Vol. 67, p. 73–74, 1912.

Advises: 1. Disinfection to be continuous by throughout maintaining a low concentration of hypochlorite. 2. Rapid circulation of water through the pool. 3. That presumptive color tests be made every few hours. 4. That by color tests a surplus of hypochlorite should be shown always present.

Dr. Roberts suggests letting the water rise vigorously, spring fashion, from the bottom of the deep end of the pool, which would induce the thorough mixing of the disinfectant in the pool. To disguise any possible taste of hypochlorite, sodium chloride (0.85%) is proposed. This fluid is far less irritating to the mucous membrane of the eyes, ears and respiratory passages, than is either pure water or any other concentration of brine.

118. The Hygiene of the Swimming Pool.

TULLY, E. J. *Am. Jour. Pub. Health*, Vol. 2, p. 186–193, New York, 1912.

There are two swimming pools at the University of Wisconsin, one for men and one for women, located at their respective gymnasiums. The pools are emptied and the floors and walls thoroughly scrubbed every Saturday, and the tank allowed to air till the following Monday, when it is filled. Investigation showed that a very considerable increase in the bacterial content occurred progressively with the use of the pools. In the case of the men's pool, 250 samples of water were treated with chloride of lime. B. coli were generally destroyed, when 12 lbs. per million gallons had been used.

In order to demonstrate in a practical way the efficiency of chloride of lime, a solution corresponding to 10 lbs. per million gallons water was poured into the pool which had been used by the students for three days; the results are tabulated below. The bacterial tabulation represents a litmus lactose agar count.

Date. Nov. 11, 1911.	Bacteria per cc. at 37° C.	Per cent. decrease.	Colon Present	
			in 1 cc.	10 cc.
Before addition	3,600			
½ hr. after	400	89%	−	+
24 hrs. after	500	86%	−	+
48 hrs. after	590	84%	−	+

The article concludes:

"The application of chloride of lime affords an efficient method of disinfection, and when used in the ratio of five tenths of available chlorine to 1,000,000 parts of lake water, a practically sterile water results. This method offers an excellent means for insuring a hygienic swimming pool."

119. University of California: Water Swimming Pools.

Engineering Record, Vol. 65, p. 443, 1912.

The out-of-doors swimming pool at the University of California developed growth of microörganisms, fostered by storing a clear ground water in an uncovered basin for the equivalent of a twenty-day period.

At first copper sulphate, 1 : 100,000, was used for killing the tetraspora and sphærocystis. Change to bleach was made on account of the danger of using the strong doses of copper salts at frequent intervals.

Treating the pool with bleach, 25 lbs. per 1,000,000 gallons every seven to ten days, has proved effective, both as an algicide and a disinfectant. Algæ growth, very noticeable before treatment, was entirely inhibited.

The value of the water for a single filling of the pool at the current rates charged by the People's Water Company is nearly $200, which makes the economic value of bleach treatment still more apparent than with the smaller indoor basins.

120. Practice at University of California.

Hyde, Charles G., from paper presented to the League of California municipalities, October 26, 1911.

"At the University of California, we apply about 15 lbs. once a week. Careful bacteriological examinations should be made to determine the necessary quantity, the best method and the proper frequency of application. At the University the hypochlorite is applied as follows: About 12 lbs. of the bleaching powder are placed in a burlap bag, and this is drawn back and forth over the surface of the water with ropes by two men, one on each side of the pool, working along the tank from one end to the other, systematically. Algæ show a decided tendency to grow on the sides of the tank; and to effectively kill such growths we place a small amount of bleaching powder in a sack, tie this to a long stick, and rub it up and down against the walls. We have found that the bacterial counts on samples collected from the pool just prior to treatment, with the amount of use this pool receives, which represents only 80 bathers a day at the present time, and in warm weather 200 per day, show only two or three colonies on agar plates incubated for 24 hours at body temperature, while on gelatin plates incubated for 48 hours at room temperature, the numbers are also usually very low. Fermentation tubes in most cases show very little gas, even after a week, perhaps only 0.2 centimeter in the top of the tube, which is of course very little."

COST OF TREATMENT.

121. Cost at Albany, N. Y., 1910.

Engineering Record, Vol. 63, p. 706–708, 1911.

	Cost per Million Gallons.
Pumping Station:	
Engineers, Fireman and oilers	$1.34
Incidental labor	.05
Coal	1.17
Oil	.07
Repairs and supplies	.18
Ice	.....
	$2.81
Preliminary Filters:	
Attendants and clerical work	$0.50
Removing, washing and replacing sand	.08
Repairs, supplies, etc	.11
	$0.69
Slow Sand Filters:	
Scraping beds	$0.06
Ejecting scraped sand	.07
Washing and replacing	.05
Reforking beds	.01
Removing ice from filters	.02
Removing, washing and restoring (entire sand layer in filters 2, 4, 5, and 8)	.37
Hypochlorite attendance	.10
Watchman	.11
Incidental labor	.58
Repairs and supplies	.24
Egg coal	.02
Ice	.....
	$1.63
Laboratory:	
Chemist	$0.28
Laboratory help	.24
Supplies	.11
Gas-86 deg. gasoline	.02
Ice	.....
	$0.65
Superintendence	.21
Total cost	$5.99

The ratio of chloride of lime was 8 lbs. per 1,000,000 gallons.
Quantity of water filtered, 6,540,687,000 gallons.

122. Baltimore County Water Company.

POWELL, S. T. *Engineering News*, Vol. 65, p. 532–534, 1910.

Cost per 1,000,000 gallons.	Filter methods. Mechanical.	Slow sand.
Interest on investment	$3.16	$4.21
Depreciation	.38	1.41
Operation and maintenance	3.77	1.53
Operating management	1.21	1.21
	$9.12 *	$8.36

Operating and maintenance itemized.

	Mechanical.	Sand.
Labor, exclusive of chemist	$0.29	$0.17
Chemicals	1.94	.01
Electricity for supply pump	.96	....
" " sample pump	.18	.18
" " blower	.01	....
" " lighting	.10	....
Heating	.13	....
Cleaning, removal of ice	.16	1.17
	$3.77	$1.53

Chloride of lime used: 12½ lbs. per million gallons.

123. Nashville, Tenn., 1910.

Engineering Record, Vol. 64, p. 337, 1911.

	Cost per Million Gallons
Sulphate of Alumina	$1.75
Bleaching powder	.08
Analysis of water	.29
Labor	.59
Inspecting water-shed	.11
Miscellaneous	.05
	$2.87
Cleaning reservoir	.25
	$3.12

124. Cincinnati, Ohio.

Engineering Record, Vol. 63, p. 293–294, 1911.

Total purification cost (1910) $4.19 per 1,000,000 gallons, including $1.93 for chemicals. Clear water in storage tank kept protected from microörganic growth by bleach. Average 8.8 lbs. chloride of lime per million gallons.

* This addition seems to be wrong.

125. Minot, N. D.

Engineering Record, Vol. 64, p. 408–409, 1911.

Under ordinary conditions 5 grains of lime, 1.5 grains of iron and 0.2 grains of hypochlorite of lime per gallon are used. Lime at Minot costs $1.50 per barrel, sulphate of iron $20 a ton and the hypochlorite of lime 4 cents a pound. Hydrated lime, which comes in 40-lb. paper bags, five to the barrel, is used instead of unslaked lime at the Minot filter plant.

126. Kansas City, Mo.

Lowther, Burton. *Engineering Record,* Vol. 65, p. 555–556, 1912.

Thirty thousand gallons are treated daily with chloride of lime, at the cost of 27 cents per million gallons.

127. Milwaukee, Wis.

A plant for temporary sterilization of 50,000,000 gallons of water was installed as result of a serious outbreak of typhoid. Six pounds bleach per 1,000,000 gallons used. Cost of plant $225. Cost of treatment given as 20 cents per 1,000,000 gallons.

128. Chloride of Lime Economical.

Kershaw, John B. C. Chloride of Lime More Economical Than Sodium Hypochlorite; The Latter Can Even Be Made From Chloride Much Cheaper Than by an Electrolytic Apparatus. *Jour. Soc. Chem. Ind.,* Vol. 31, p. 54–57, 1912.

It is practically cheaper to manufacture sodium hypochlorite from bleaching powder.

As regards the use of electrolytic hypochlorite for sanitary purposes, the analysis of the official figures of costs for the municipal Poplar installation of the Hermite process, does not appear to be favorable to the adoption of the process elsewhere or to the extension of the existing plant at Poplar. It would seem quite unnecessary to spend between £100 and £200 per annum in producing (in an electrolytic plant) 1,218 kilos. of active chlorine, when this could be purchased in the form of bleaching powder, in the open market for £25 or less. The officials' argument that this 50,000 gallons of dilute hypochlorite liquid (costing say £150) has replaced an earlier expenditure of £533 upon other liquid disinfectants does not meet the case.

129. Chloride of Lime more Economical than Electrolytic Installations.

Phelps, Earle B. Disinfection of Sewage and Sewage Effluents. (From paper read before the Am. Soc. of Municipal Improvements.)

In the investigations made, the subject of electrolytic processes of treatment received considerable attention. Many such processes have been developed, and a few have actually been installed. The claims of some of them are so

ridiculous that the process disbars itself from scientific consideration. There seems to be something about such terms as "electrolytic" which appeals strongly to the layman, and this weakness on the part of local boards of public works has been played upon in many instances for the purpose of marketing certain patent processes of very dubious merit. It happens that chlorine is practically a by-product of the much more important alkali industry and that its price is consequently fixed at almost the cost of materials and freight. Granting to such a process unusually cheap electric current and theoretical efficiencies, the cost of manufacture on a scale small enough for an ordinary sewage disposal plant would still be above the market-price of bleaching powder.

SOME CITIES USING CHLORIDE OF LIME IN WATER PURIFICATION.

130. Consumption of Purified Water in American Cities.

Johnson, George A., in paper read before the Convention of the American Public Health Association, 1910.

In 1890, less than 200,000 people in this country were being supplied with filtered water, and 90% of this water came from rapid sand filters which bore little resemblance to filters of this type built during the last ten years. In 1900 the number of people supplied with filtered water had increased to 1,860,000, and in 1904 to 3,160,000. At the present time, nearly 8,000,000 people, or over 22% of the urban population of continental United States are being supplied with filtered water.

131. A Temporary Water Disinfecting Plant at Brainerd.

Bass, Frederic. *Engineering Record*, Vol. 63, p. 161, 1911.

132. Results at Chicago.

Jennings, C. A. Operating Results of the Bubbly Creek Filter Plant, Chicago. *Engineering Record*, Vol. 62, p. 340–342, 1910.

133. Chicago, Ill.

Wisner, George M. Report to the Sanitary District of Chicago, October, 1911, pages 69, 70, 72.

It is perfectly practicable, in accordance with modern sanitation, to provide an emergency treatment which will protect the health of the citizens in this district. Sterilization by the use of hypochlorite of lime, in small amounts, is the proper remedy. The amount of the chemical required is small, being approximately 5 lbs. per million gallons, and the estimated cost, including interest charges and depreciation, as well as operating expenses, would be about 35 cents per million gallons pumped. At present the water supply of Chicago, with the exception of that from the Sixty-Eighth Street crib, is in a fairly satisfactory condition. It is, however, open to chance pollution due to shipping.

Estimated cost of Disinfection of Entire Water Supply.

Year.	Population.	Average Daily Pumping in Million Gallons.	Annual Cost.
1911......	2,250,000	450	$57,500.00
1922......	3,000,000	600	76,700.00
1935......	3,800,000	760	97,100.00
1942......	4,200,000	840	107,300.00

Estimated Cost of Filtration.

Year.	Population.	Daily Average Pumping Million Gallons.	Annual Cost.
1922......	3,000,000	600	$1,860,000.00
1935......	3,800,000	760	2,280,000.00
1942......	4,200,000	840	2,530,000.00

134. Filtered Water at Cincinnati.

Engineering Record, Vol. 63, p. 113, 1911.

135. Cleveland, Ohio.

Engineering News, Vol. 64, p. 367, 1911.

The present water sterilizing plant at Kirtland Street, Cleveland, had been installed to avoid an impending typhoid fever epidemic. The water supply of the city was periodically threatened with gross pollution, principally from the discharge of the Cuyahoga River; 0.8 part per 1,000,000 of available chlorine is being used. The chemical is applied to correspond with the operation of the pumps. In the lake water normally there are present 5 parts per 1,000,000 gallons of chlorine, according to the usual water analysis.

136. Cleveland, Ohio.

Jackson, D. D. Report to the City of Cleveland, 1912.

Jackson, when called in to remedy the defects of the lake water, brought out a significant fact, proving removal of pathogenic germs by their settling out in the municipal water pipe system. The epidemic was spread in uniform virulence over the semi-circle of about one mile radius, adjacent to the lake shore, and fell off entirely where the drinking water had traveled longer distances.

Within the affected area, samples from stop cocks taken after the water had been at rest, showed abundance of B. coli.

137. Chlorination at Cleveland, Ohio.

Jackson, D. D. *Engineering Record*, Vol. 65, p. 669–670, 1912.

The present chlorinating plant consists of a small mixing tank 4 feet in diameter and 3 feet, 4 inches deep, equipped with a mechanical stirrer. There are two 11 foot, 8 inch diameter solution tanks, 7 foot, 5 inches deep; a 1% mixture is used, the feed being controlled by two orifice tanks with float valves. The daily pumpage is about 70,000,000 gallons, so that from 11 to 18 lbs. of hypochlorite per million gallons is used, corresponding to an amount of chlorine of from 0.5 to 0.7 parts per million. Sudden changes in pumpage, together with the sometimes great variation in the strength of the individual drums of chloride of lime, has at times been a source of difficulty in the application of the treatment. This difficulty was greatest at the time when it was thought that 0.8 parts per million of chlorine, 25 lbs. chloride of lime per million gallons, was necessary. It is now found that from 0.5 to 0.7 parts is sufficient. Any amount in excess of 0.8 part produces during cold weather objectionable tastes and odors. The article also refers to some experimenting in the use of liquid chlorine for sterilization.

138. Council Bluffs.

A Sterilization Plant for Turbid Water at Council Bluffs, Iowa. *Engineering Record*, Vol. 62, p. 334–335, 1910.

139. Hypochlorite of Lime Treatment Plant at Erie, Pa.

Jennings, C. A. *Engineering Record*, Vol. 64, p. 100, 1911.

140. The Municipal Water Purification Plant of Grand Rapids.

Engineering Record, Vol. 64, p. 379–381, 1911.

141. Grand Forks Rapid Sand Filters.

Lykken, H. G. *Engineering Record*, Vol. 63, p. 698–699, 1911.

When it is considered that at all times the water is highly polluted, and that during the greater part of this period the B. coli ran from 30 to 40 per cubic centimeter, the efficiency of the treatment becomes apparent. In no way is the efficiency of the hypochlorite impaired by being added to the water in its muddiest conditions, as it enters the settling basins together with the alum. The hypochlorite is, of course, the chief agent accountable for the bacteria efficiency, but being added in the small quantity of 1 lb. to each 100,000 gallons of water, certainly no objection can be raised against its use. The cost is negligible.

142. Disinfecting Lake Water with Calcium Hypochlorite.

Engineering Record, Vol. 65, p. 360–362, 1912.

143. Temporary Hypochlorite Plant.

POETSCH, CHARLES J. A Temporary Hypochlorite Plant for Treating the Water Supply of Milwaukee, Wis. *Engineering News*, Vol. 64, p. 335, 1910.

144. The Mechanical Filtration Plant at Minneapolis.

Engineering Record, Vol. 64, p. 586–590, 1911.

Dissatisfaction led in 1909 to an investigation into the possibilities of purifying the river water or securing a supply from an entirely new source. Mr. Rudolph Hering of New York was appointed to investigate the merits and demerits of sources of supply. On March 17, 1910, he reported in favor of the Mississippi River plan, recommending mechanical filtration and sterilization with hypochlorite of lime. This plan was adopted and construction work on the filters was in progress, November, 1911.

145. Minnesota Cities.

The following references on cities in Minnesota are taken from the biennial report by the State Board of Health, 1909–1910:—

Brainerd. Population about 9,000. Water supply from Mississippi River. Supply is polluted. Has been cause in recent years of considerable typhoid. In October, 1910, a hypochlorite disinfecting plant installed and operated continuously since by G. W. Jevne, a graduate of the engineering college, State University. Water supply now free from typhoid contamination.

Breckenridge. Population, 2,000. Water supply from the Ottertail River. Until recently water received no purification and was cause of much typhoid. Purification plant now constructed, consisting of settling tank and rapid sand filters. A disinfecting plant, to be used in connection with sand filter, has been recommended by the State Board of Health, as no filter plant without some disinfecting auxiliary can be relied upon to produce at all times an effluent free from pathogenic bacteria when they are present in the raw water as they are in this stream.

Chisholm. Population about 5,000. Water supply supplied from Monroe mine. However, even with the excellent superintendence which this plant receives, there is danger of an epidemic from this water, as no mechanical filter, without some sterilizing agent can, at all times, be relied upon to produce an effluent free from pathogenic organisms when such are present in the untreated water. A disinfecting plant should be installed, the cost not to exceed $500,000, and the operating expenses would not be over $1 per day.

Crookston. Population 8,000. Water supply mainly from three artesian wells. Present filter needs remodeling. Adequate sedimentation basin should be constructed with proper appliances for the administration of the chemicals. A disinfecting plant should be installed and operated in connection with filter to insure against passage of pathogenic bacteria into the mains.

St. Cloud. Population about 10,000. Transients who do not know the local situation are in danger of drinking such water unawares. Water should

be purified so as to remove all such danger. A disinfecting plant, while not removing physical impurities of water, such as color, turbidity, taste or odor, would remove pathogenic bacteria, the cause of typhoid and dysentery. Cost of such a plant would not be over \$500, operating expenses would not be over \$1 per day.

Detroit. Population 3,200. Water now taken from Detroit Lake. The water works intake pipe is about 300 feet from the shore and in only eight feet of water. With this very unsanitary condition of the source, the city should take immediate steps for purification of the water supply. Some kind of disinfection, such as hypochlorite treatment, should be used. Such a plant would cost in this case, not over \$400 with operating expenses not over 75 cents per day.

Ely. Population about 4,000. Some danger that the water supply might be contaminated. No mechanical filter can, without some form of disinfection, be depended upon to produce at all times an effluent free from pathogenic bacteria. City should install hypochlorite disinfecting plant to be operated in conjunction with the present filters.

146. Mechanical Filtration at Montreal.

The Rapid Mechanical Filtration Plant of the Montreal Water and Power Company. *Engineering Record,* Vol. 65, p. 260–261, 1912.

147. Water Disinfection and Winter Typhoid.

Meadows, J. O. The Apparent Effect of Water Disinfection on Winter Typhoid at Montreal. *Engineering News,* Vol. 65, p. 80, 1911.

148. Water Supply of Montreal.

Engineering Record, Vol. 64, p. 280–281, 1911.

After investigating other possible sources of supply it was decided to continue using the St. Lawrence River water after subjecting it to double filtration and sterilization with hypochlorite. A site for the works was selected near the end of the existing intake conduit and active construction is now under way. The improvements also include an extension of the existing river intake to a point 1,200 feet from shore, the contract for which was let in 1910.

149. Sterilization of Water at Montreal.

Dupont, G. La Stérilisation de l'Eau d'Alimentation au Moyen du Chlorure de Chaux à Montréal, Canada. (Sterilization of Drinking Water with Chloride of Lime, at Montreal.) *Genie Civil,* Vol. 57, p. 7–10. Paris, 1910.

150. Water Treatment at Omaha, Neb.

Marshall, Francis H. Water Treatment by Coagulation, Sedimentation and Hypochlorite Disinfection at Omaha, Neb. *Engineering News,* Vol. 65, p. 399–401, 1911.

151. Typhoid Fever at Ottawa, Ont.

Engineering News, Vol. 65, p. 214, 1911.

The typhoid fever outbreak in water during 1910 is now ascribed to the ill-advised temporary use of a water intake near the shore where the water is polluted. A chloride of lime plant was installed and typhoid has gone down. The epidemic probably would have been checked earlier, had the recommendation of a hypochlorite plant by Mr. Allen Hazen, C.E., of New York on October 5, 1910, been acted upon promptly.

152. New Water Purification Works at Ottumwa.

Engineering Record, Vol. 65, p. 494–495, 1912.

153. Use of Hypochlorite in Paris.

The Use of Hypochlorite to Treat the Water Supply of Paris. *Engineering News*, Vol. 66, p. 590, 1911.

154. The Operation of the Pittsburgh Water Purification Works.

Engineering Record, Vol. 64, p. 447–448, 1911.

155. Pittsburgh Filtration Works.

FIELD, F. E. *Proc. Eng. Soc. of West. Penn.* Vol. 26, p. 237–269, 301–315. Pittsburgh, 1910.

156. The Toronto Filtration Plant.

LONGLEY, FRANCIS E. *Engineering Record*, Vol. 63, page 264–268, 1911.

HISTORICAL RÉSUMÉ OF CHLORIDE OF LIME IN WATER STERILIZATION.

157. Historical Résumé of Hypochlorite Treatment.

JOHNSON, GEORGE A. *Journal of the American Public Health Association*, Vol. 1, p. 562–574. Urbana, Ill., 1911.

The use of hypochlorites for the destruction of objectionable bacteria in water and in sewage has been a matter of considerable active investigation on a small scale for some 20 years, although it was studied in connection with the deodorization of the London sewage, as reported upon in 1861 by the Royal Commission on Sewage Disposal. The investigators who have studied the action of hypochlorites on bacteria are numerous, and include such well-known workers as Ballner, Barsenge, Clark, Deiter, Dibden, Digby, Dunbar, Elsner, Fermi, Fowler, Gage, Houston, Hunerman, Kauffmann, Kellerman, Kimberly, König, Korn, Kranepuhl, Kurpjuweit, Lodi, McGowan, McLintock, Nissen, Phelps, Pratt, Proskauer, Remele, Rideal, Schumacher, Schwartz, Shenton, Sickenberger, Traube, Webster, Woolf, Zirn and others.

The late Thomas M. Drown observed that the American Public Health Association recognized the value of hypochlorites as early as 1888, and the experience and results obtained at Maidstone, England, in 1897, and at Lincoln, England, in 1904, are too well known to require repetition. The use of hypochlorites, at Worthing, England, Middlekerke, Belgium, Nice, France, Poplar, England, Havana, Cuba, Vera Cruz, Mexico, Brewsters, N. Y., Red Bank, N. J., Baltimore, Md., Union Stock Yards, Chicago, Ill., Boonton, N. J., and numerous other places, has supplied valuable information which has in all ways confirmed the earlier favorable ideas of the applicability of these compounds for general sterilizing and deodorizing purposes.

Up to 1908 the use of hypochlorites in the purification of public water supplies had not received serious consideration. Most of the information then available was fragmentary and more or less indefinite in character, and the process had not gained general credence. The first demonstration in this country on a practical scale of the usefulness of hypochlorites, in connection with water purification was made at the filter plant of the Chicago Stock Yards, on the recommendation and under the direction of the writer, in the fall of 1908. Following directly on the heels of the spectacular results obtained at Chicago, came the adoption of this process for the sterilization at Boonton, N. J., of the impounded and unfiltered water supply of Jersey City, with which the writer was also connected. The results obtained at these two places were given wide publicity, and almost immediately the use of hypochlorites either intermittently or continuously, spread throughout the United States. Among its users at this time are many of the largest cities of North America, including Brooklyn and New York, N. Y., Cincinnati and Columbus, Ohio, Harrisburg, Philadelphia and Pittsburgh, Pa., Hartford, Conn., Montreal, P. Q., Nashville, Tenn., and St. Louis, Mo.

OTHER METHODS OF WATER STERILIZATION.

158. Ozone.

Nature, Vol. 88, p. 551–654. London, 1912,

It is only within the last decade that the use of ozone for the purification of water has been commercially employed.

159. The Purification of Water by Ozone.

Rideal, S. *Roy. San. Inst. Jour.*, Vol. 30, p. 32–57. London, 1909.

160. The Ozone Plant at St. Petersburg, Russia.

Engineering Record, Vol. 63, p. 473, 1911.

161. The Ozone Water Purification Plant at St. Petersburg.

Engineering News, Vol. 66, p. 783, 1911.

162. Sterilization of Water by Ozone in St. Petersburg.

Metallurgical and Chemical Eng. Vol. 9, p. 213, New York, 1911, and Vol. 10, p. 712, 1912.

163. Experiments with Ozone in Kansas City.

Cross, W. M. *Engineering News*, Vol. 67, p. 779, 1912.

Experiments made at Kansas City with ozone indicated that, although it was possible to sterilize to a satisfactory degree all of the city water, the expense of installing and maintaining the apparatus would be prohibitive.

164. Use of Ultra-Violet Light in France.

Sterilization of Polluted Water by Ultra-Violet Rays at Marseilles, France. *Engineering News*, Vol. 64, p. 633, 1910.

165. Sterilization of Drinking Water by Ultra-Violet Light.

Courmont, J. *Chemiker Zeitung*, 1911, Vol. 35, p. 806.

The author discusses the remarkable sterilizing power of the ultra-violet light from a quartz mercury vapor lamp. For sterilizing water, which is comparatively transparent to the radiation, it is sufficient to place the lamp in the axis of a cylindrical vessel 60 cm. in diameter. Liquids containing colloids (wine, beer, peptone solution, etc.) absorb the ultra-violet rays rapidly, and therefore sterilization is limited to the surface layer. It is therefore necessary that for greatest efficiency the water to be sterilized must be as clear as possible.

166. Sterilization of Water by Ultra-Violet Rays.

Grimm and Weldert, Mitt. K. Prüf.-Anst. f. Wasserversorg. u. Abwasserbeseit., 1911, No. 14, p. 85–112. (*Chem. Zentr.*, Vol. 15, p. 1454. Berlin, 1911.)

The experiments were made with a mercury vapor lamp of 1200 candle power enclosed in a double-walled quartz vessel, through which the matter was passed. Clear water containing less than 100 bacteria per cc. could be sterilized when passed through the apparatus at a velocity of 0.55 cu. m. per hour, but with water very rich in bacteria, sterilization was effected only when the velocity did not exceed 0.45 cu. m. per hour. Turbidity, and the yellow coloration due to colloids, such as is observed in peaty waters, destroy the efficiency of the treatment for practical purposes. The cost of the treatment is very high compared with that of existing processes.

167. Pure Water for Cities.

A recent report from the United States Consular Agency at Berlin is of interest as it furnishes brief information of what has been done in European cities in sterilizing drinking water and so of freeing city water supplies from dangerous germs.

Plants for what is known as the ozone treatment of water have been introduced at Wiesbaden, Fadenhorn, Hermenstead and Chemnitz, in Germany; Paris, Nice, Charteres and Dinard, in France; Florence, Italy; and St. Petersburg, Russia.

These ozone plants, it seems are operated through an invented process and the treatment can be either upon a wholesome scale for an entire city, or upon small scale for a limited water supply.

It is claimed for the process that it effects the complete destruction of all bacteria of typhoid, cholera and dysentery that may be contained in the water. It is claimed that the treatment also minimizes what are regarded as harmless bacteria in water, but which sometimes unpleasantly affect the taste.

It is not claimed for the process that it is as cheap as simple filtration, but it is said that it is much more effective as a purification method. Ozonization systems have been introduced in this country, and in a few instances, city supplies on this side of the ocean have been thus treated.

The Berlin report estimates the cost of purification upon a large scale—a whole city supply—at one-half cent per cubic yard, or about one cent per 1,000 gallons. The cost is estimated to include the maintenance cost of the purification plant.

168. Use of Ozone for Purifying Water.

Daily Consular and Trade Reports, No. 237, p. 143, Washington, October 8, 1912.

169. Sterilization of Water by Ozone in St. Petersburg.

Metallurgical and Chemical Engineering, Vol. 10, p. 712. New York, 1912.

"The Uprava (Magistrate) and the Duma (City Council) of the City of St. Petersburg, in Russia, have agreed unanimously to adopt the ozone method in connection with rapid filtration for the cleaning and sterilization of the water for the city, supplied by the water works at Spalernaja, in view of the good results obtained from ozone water works already in operation at Penkowaja.

"Advertisements for proposals for the plant have already been issued, the city having appropriated 10,000,000 rubles for the project. The awarding of contract, based on estimates received, is to take place in the near future. The original ozone purification plant of the water works of St. Petersburg was described in detail in an article by Dr. G. Erlwein, in our Vol. IX, p. 213 (April, 1911)."

FURTHER BIBLIOGRAPHICAL REFERENCES ON STERILIZATION OF WATER AND PURIFICATION.

170. Purification and Sterilization of Water.

Rideal, S. *Jour. Soc. of Arts*, Vol. 50, p. 717–725; 729–737; 741–750; 755–767. London, 1902.

171. Traube's Chloride of Lime Process.

ENGELS. Studien über die Sterilization von Trinkwasser auf Chemischem Wege: Traube's Verfahren mit Hilfe von Chlorkalk. (Studies on Sterilization of Potable Water by Chemical Means: Traube's Chloride of Lime Process.) *Centralbl. f. Bakteriologie, Parasiten Kunde u. Infections Krankheiten.* I. Vol. 32, p. 495–521. Jena, 1902.

127. Different Methods of Purifying Water.

MAIGNEN, P. A. *Proceedings Engineers' Club of Philadelphia,* Vol. 24, p. 1–69, 1907.

173. Sterilization of a Potable Water Supply by Means of Bleach.

LEAL, J. L. *Journal of the Engineers' Society of Pennsylvania,* Vol. 1, p. 382, 1909.

174. Hygienic Valuation and Control.

SPITTA. Neue Hilfsmittel für die Hygienische Beurtheilung und Kontrolle von Wassers. (New Methods for Hygienic Valuation and Control of Waters.) *Arb. a. d. Kais. Gesundheitsamte,* Vol. 30, p. 463–482. Berlin, 1909.

175. Disinfection as an Adjunct to Water Purification.

CLARK, H. W. and GAGE, STEPHEN DEM. With dicussion. *Journal of the New England Water Works Association,* Vol. 23, p. 302–323. Boston, 1909.

176. Sterilization with Hypochlorites.

HYDE, CHARLES GILMAN. The Sterilization of Water Supplies By the Use of Hypochlorites. From paper presented to League of California Municipalities, October 26, 1911.

177. Hypochlorite Treatment of Public Supplies.

JOHNSON, GEORGE A. Hypochlorite Treatment of Public Water Supplies; Its Adaptability and Limitations. *Engineering Record,* Vol. 62, p. 321–323, 1910.

178. Water Purification.

SPITTA, O. Die Wasserversorgung. In *Handbuch der Hygiene,* Leipzig, 1911.

179. Testing of Water and Sewage.

OCHLMUELLER, W. and SPITTA, O. Die Untersuchung und Beurtheilung des Wassers und der Abwassers. 3d Ed. Berlin, 1910, 422 p.

A good bibliography, pp. 383–409.

180. Sterilization of Public Water Supplies.

JOHNSON, GEORGE A. *Assn. of Eng. Soc. Jour.* Vol. 46, p. 12–24; 32–45 (with discussion). Boston, 1911.

181. Water Supply for Country Homes.

McVey, Karl A., *Univ. of Mo. Eng. Exp. Sta. Bull.* No. 2. Columbia, Mo. 1910.

182. Purification of Public Water Supplies.

Lea, R. S. Some Recent Developments in the Purification of Public Water Supplies (with discussion). *Canad. Soc. of Civ. Eng. Trans.* Vol. 24, p. 250–269. Montreal, 1910.

183. Modern Methods of Water Purification.

Don, Joh. and Chisholm, J. London, 1911. 368 p.

184. The Use of Hypochlorites in Water and Sewage Purification.

Newlands, James. *Conn. Soc of Civ. Eng. Papers,* Vol. 27 (1910), p. 87–95. New Haven, 1911.

185. Chlorine and Bacteria.

Walker, Leslie C. The Eliminating Effect of Chlorine upon the Bacteria of a River Water. *Assn. of Water Engineers Trans.,* Vol. 15, p. 187–214. London, 1910.

NATURE OF SEWAGE.

186. Appearance and Character of Sewage.

Dunbar, Prof. Dr., Hamburg State Hygienic Inst., (from "Principles of Sewage Treatment"). Translated by Calvert, H. T., London, 1908, p. 271.

The sewage of a town, sewered by the water-carriage system, is a gray dirty liquid, possessing an unpleasant sweetish odor, scarcely noticeable in the open air and not repugnant, even in the sewers.

It reaches the outfall in a continuous stream, upon the surface of which may be seen matches, corks, fruit skins, vegetable remains and lumps of fecal matters.

If a fine sieve is placed in the current of the sewage so as to retain solid matters, and these are examined, they will be found in addition to the above mentioned, to consist of flocculent and fibrous material, rags and small bits of paper, with perhaps a few hairs and other similar substances.

A sample taken in a glass vessel looks like water, which has been used for washing and cleaning purposes, and on standing, a comparatively small amount of dirty, gray, slimy material settles out, without materially altering the appearance of the sample.

Even after standing for twenty-four hours, little further can be noticed. The liquid remains almost quite as turbid after passing through fine filter paper; but if it is passed repeatedly through the same filter paper, it becomes clearer, as the pores of the filter become partly stopped by the material retained.

Finally, a clear filtrate will be obtained without leaving any appreciable residue on the filter.

If this clear liquid is allowed to stand for several days, it first begins to smell slightly offensive, and then distinctly of sulphuretted hydrogen, caused by decomposition of the putrescible matters in solution, and finally the odor gradually disappears.

An unfiltered sample subjected to similar treatment also becomes clear after a somewhat longer period, without any increase in the amount of sediment; in fact, the sediment gradually becomes smaller in amount, until only a little flocculent matter remains, and this, under the microscope, appears to consist entirely of microörganisms. The sample is now fully putrefied, and, if it has been kept in a closed vessel, it will smell of sulphuretted hydrogen, but this soon disappears upon opening the vessel.

187. Dissolved and Solid Matters.

Fuller, George W. Dissolved and Solid Matters in Representative Sewage from Combined Sewers of American Cities, with Estimated Volumes per Capita Daily. Sewage Disposal, 1912. Abstracted from Table 6, p. 10.

		Parts per Million.				
		Lawrence, Mass.	Worcester, Mass.	Providence, R. I.	Columbus, Ohio.	Chicago, Ill.
Average daily flow, gals.		.....	118.0	99.0	121	289
Oxygen Consumed, 5 min. 212°		55.7[1]	120.7	93.6	56	38
Dissolved matters	Total	568.0	617.7	1318.0	811	...
	Mineral	394.0	361.2	941.0	702	...
	Org. and Vol.	174.0	256.5	377.0	109	...
Suspended matters	Total	149.0	255.8	397.0	215	141
	Mineral	36.0	78.0	53.5	134	81
	Org. and Vol.	113.0	177.8	343.5	81	60
Total solid matter	Total	717.0	873.5	1715.0	1026	515[2]
	Mineral	430.0	439.2	994.5	836	...
	Org. and Vol.	287.0	434.3	720.5	190	...

188. New York Sewage Composition.

Winslow, C.-E. A. Am. Museum of Natural History Guide Leaflet, Series No. 33, April, 1911.

New York sewage contains less than one per thousand in total solids, half of which is organic; or in 600,000,000 gallons daily flow, about 900 tons of dry organic matter, which is discharged into New York harbor.

Dry suspended solids in New York City Sewage (from Report of the Metropolitan Sewage Commission of New York City, April 30, 1910):

[1] Two minutes boiling.
[2] Figure made from limited determinations.

Material	Tons per 1,000 inhabitants annually.	Tons entering New York Harbor annually.
Feces	14	77,600
Toilet paper and newspaper	8	44,300
Soap and washings	11	60,900
Street wastes	8	44,300
Miscellaneous	6	22,200
	45	249,300

SEWAGE BACTERIA.

189. Bacterial Life in Sewage.

Fuller, George W. Sewage Disposal, New York, 1912, p. 84–85.

Sewage contains a complex mixture of organic substances and numerous kinds of bacteria. Practically all organic matter in water decomposes in the presence of bacteria. The rate and manner of decomposition varies much, depending upon numerous factors.

So long as dissolved atmospheric oxygen is available, aërobic decomposition takes place. When oxygen, dissolved in the water as a gas or available from certain compounds, is exhausted, then bacterial decomposition proceeds upon an anaërobic basis.

So long as available oxygen is present the sewage is fresh. When anaërobic decomposition begins it is stale. For a time, it is the soluble organic matter that is then decomposed through the protoplasmic activities of the bacterial cells. Sooner or later enzymes are excreted by the anaërobic bacteria and these soluble products proceed to liquefy and gasify suspended organic matters. This is spoken of as the septicization of sewage.

Some of the products of decomposition are of a simple character, well known in nature. Part of them are odoriferous and others are not. If we subtract from the original organic constituents of sewage the sum of all of the well-known simple decomposition products and also the residual humified matter, there are still left numerous intermediate compounds which are dissolved in sewage and about which data are limited.

This subject of decomposition is important, as it is intimately associated with the efficiency and economy of disposal projects.

190. Sewage Bacteria.

Fuller, George W. Sewage Disposal, New York, 1912, p. 123.

Sewage bacteria include at times the germs of typhoid fever, Asiatic cholera, and diarrhœa. These diseases are abnormally prevalent in communities receiving in an unpurified condition a water supply that is sewage polluted.

There is no room for doubt about a little sewage creating much mischief if it enters a water supply only for a few hours at rare intervals. It is a serious

menace to the public health. Sewage bacteria should not be delivered to water consumers. They should either be prevented from entering the water supply if that is practicable, or if such prevention is impracticable they should be removed by efficient filtration or sterilization or both.

There are other means of transmitting water-borne diseases than by the public water supplies. This is well shown by the variations in death rates of neighboring cities which receive the same public water supply.

191. Pathogenic Germs in Sewage.

PHELPS, E. B. The Disinfection of Water and Sewage. *Proceedings of the Engineers' Club of Philadelphia*, Vol. 27, p. 135–151, 1910.

The most exhaustive study of the problem of pathogenic germs in sewage that has been made, was carried out by Houston under the auspices of the Royal Sewage Commission of Great Britain, as a result of which it was concluded that "the biological processes at work in the filters were not strongly inimical, if hostile at all, to the viability of pathogenic germs." It is the speaker's opinion, based upon all the available evidence and upon a long personal experience with investigations of this character, that the removal of pathogenic germs by rapid filtration methods is not greater than would be accomplished naturally in the streams in an equal period of time. That such removal is considerable is frankly admitted. In the course of a few hours or of a day, under natural stream conditions, great improvement is always noted. This improvement, however, has not been sufficient to prevent the disastrous typhoid fever epidemics of Lawrence, Mass., Butler, Pa., Ithaca, N. Y., and other places too numerous to mention.

Houston performed the following experiment: B. pyocyaneus, a pathogenic organism, was applied to the top of a trickling filter, and ten minutes later the bacillus appeared in the effluent, continuing to be discharged for ten days. In a similar manner the same organisms were found to pass through a septic tank and a contact filter successively and to persist in both for nine days.

192. Removal of Bacteria by Filters.

Removal of 20° C. and 40° C. Bacteria by Sewage Filters. Condensed from the Report of State Board of Health, Massachusetts, 1910, Page 269.

	Bacteria per cubic centimeter.			Per cent. of bacteria removed.		
		40° C.			40° C.	
	20° C.	Total.	Red.	20° C.	Total	Red.
Lawrence street sewage	1,507,300	400,700	302,600	.....	.....	.....
Regular sewage	2,095,600	448,100	363,600	.....	.....	.....
Settled sewage	1,386,300	254,900	207,900	33.80	43.00	42.90
Effluent, Strainer E	874,200	141,900	115,800	58.50	68.40	68.20
Andover regular sewage	3,476,100	646,500	539,200	.....	.....	.....
Andover settled sewage	1,461,800	360,600	271,400	58.00	44.30	49.70
Fresh sewage	3,241,600	597,700	553,000	.....	.....	.....
Effluent, Imhoff tank	1,730,000	343,200	189,200	46.60	42.60	65.80
Effluent, contact filter:—						
	553,300	74,100	60,100	36.70	47.90	48.10
	1,105,600	342,400	290,300	47.20	23.70	20.30
	2,123,500	184,700	129,800	.....	46.00	31.20
Effluent, trickling filter:						
(entire)	169,400	17,700	13,300	87.90	93.06	93.60
(2 feet) Depth of filter medium	406,800	41,700	32,400	70.70	83.70	84.40
(4 feet)	287,300	26,000	20,100	79.40	89.80	90.34
(6 feet)	254,500	18,200	13,700	81.70	92.85	93.42
(outlet)	198,100	20,000	15,400	85.80	92.15	92.59

193. Bacteria in Sewage and Effluents.

Phelps, E. B. Bacteria in Sewage, Septic Effluent and Trickling Filter Effluents, Boston, 1906. *Water-Supply Paper*, No. 229, U. S. Geological Survey, Washington, 1909, p. 11.

Source of Samples.	Bacteria per cubic centimeter; lactose agar at 370° C.	B. coli; positive tests in one-millionth of a cubic centimeter. *Per cent.*
Sewage	1,300,000	65
Trickling filter receiving sewage	750,000	35
Septic effluent	1,650,000	66
Trickling filter receiving septic effluent	750,000	35

Prof. E. B. Phelps states that bacteria of various groups and certain specific organisms pass through such filters in practically the same proportions as the bacteria as a whole; and that, in the absence of any information to the contrary, it should be assumed that such filters have no greater effect on the typhoid and other pathogenic organisms than on B. coli, B. pyocyaneus, sewage streptococci, or the different groups of sewage bacteria.

194. Disinfectants and Nitrification.

Clark, H. W. Influence of Chemical Disinfectants on Nitrification: Sand Filters. *Jour. of the Assn. of Eng. Societies*, Vol. 46, p. 33, Boston, 1911.

Mr. Clark, chemist of the State Board of Health of Massachusetts, states that sand filters receiving sewage containing phenol have been continued in operation until the sewage contained 133.0 parts per 100,000 without checking nitrification; with mercuric chloride, 286.0 parts per 100,000; with formalin, 400.0 parts per 100,000; with arsenic, 400.0 parts per 100,000; with bleaching powder, 2.5 parts per 100,000 in connection with trickling filters. These experiments have shown very clearly the resisting power of the bacteria in the filters and their ability to continue nitrification under these adverse conditions.

195. The Bacterial Control of Sewage Purification.

Lederer, A. and Bachmann, F. *Engineering Record*, Vol. 64, p. 88, 1911.

Sampling is mentioned as one of the main difficulties that stand in the way of obtaining uniform results, the sewage showing variations between 70,000 and 170,000 and more bacteria per cubic centimeter after one minute interval.

Attention is drawn to the fact that removal of pathogenic bacteria is not affected nor aimed at by the ordinary process of sewage purification.

196. Bacterial Removal by Filters.

Pearse, Langdon. The Sewage Disposal Problem in the United States and Abroad. *Jour. Western Society of Engineers*, Vol. 16, p. 565–591, Chicago, 1911.

No one now claims that a sprinkling filter is all-sufficient for removing bacteria. Perhaps 80% may be removed with a sprinkling filter.

However, when bacterial removal is required, the effluent can be treated by disinfecting it with chloride of lime, which readily and cheaply removes all the bacteria. This is a modern finishing process and has been adopted in some of the plants of this country, particularly Baltimore, where an effluent thoroughly free from bacteria was desired to protect the shell-fish industry below the outlet of the sewage disposal works.

INFECTION OF SEWAGE BY DELAY; SEEDING.

197. Infection of Sewage.

Fuller, George W. Sewage Disposal. New York, 1912, p. 90–91.

Smooth Interior Surfaces in Sewerage Pipes.—Where the interior surfaces of the sewers are rough and where projecting masonry allows deposits to be built up in front of it, it is quite possible that in these deposits anaërobic conditions are established in a manner and to an extent that is much more conducive to objectionable odors than is generally considered in this country by those who deal with reasonably well-designed and constructed sewers.

Flushing.—First-class sewerage practice calls for the installation of flushing tanks at the head of all sewer lines in order to wash away stranded particles of fecal matter in those portions of the sewer where the ordinary flow is insufficient to maintain a scouring velocity. Such flushing is sometimes done by automatic flush tanks discharging every hour.

Seeding.—The statements above are sufficient to point out the advantage of having clean sewers. They do not fully exploit, however, the possible disadvantage of deposits within a sewer system becoming seeded with suitable bacteria, so that where sufficient time elapses anaërobic decomposition may progress to the point of reducing putrefactive enzymes.

Aëration.—The introduction into sewage of more atmospheric oxygen than is left in the water supply of which the sewage was initially composed, has perhaps more merit than has generally been considered hitherto for some large trunk sewers. While this would not provide substantial oxidation of organic matters, or increase the oxygen beyond the saturation point, it would afford the advantage of prolonging bacterial operations on an aërobic basis. From the standpoint of the "oxygen balance," it would make the sewage more stable. This aërating idea is unwittingly availed of in sprinkling filters within certain limits, and constitutes one of the reasons why sprinkling filters have a greater capacity per unit volume of filtering material than contact filters.

198. Sewage Non-Putrescent at Outfall.

Hering, Rudolph. Important that Sewage be Delivered at the Outfall in a Non-Putrescent Condition. In the Report of the Committee of the Amer. Med. Assn. (*Jour. Am. Med. Assn.*, Vol. 57, p. 1903–1907, Chicago, 1911).

Dr. Rudolph Hering states: "All oxidizing processes can effect an inoffensive purification of the liquid when it has not been allowed to become septic. It is therefore now greatly to be desired that sewage be delivered to the works as fresh as practicable.

Delivery of the sewage can be facilitated by a well-designed and a well-maintained sewage collecting system, giving good velocities at all points and furnishing no opportunities for local deposits or for retention of decomposing matter by projections or rough surfaces.

TREND OF PRESENT DAY DEVELOPMENT IN SEWAGE DISPOSAL.

199. Present Tendencies.

Fuller, George W. Sewage Disposal, New York, 1912, p. 212.

"Many sanitarians and medical men are clamoring stoutly for the elimination of all sewage matters from American streams. Literally this is impossible. No longer can there be streams of pristine purity in populous districts. This is one of the penalties of civilization.

"On the other hand, it may be freely stated that many streams are now polluted to a disgraceful degree. Corrections are most urgently needed.

"While it is possible to purify sewage to almost any degree, the expense of doing so as thoroughly as called for by the sentimentalities is prohibitive in some instances. Much good is accomplished by treating the public water supplies so as to make them above reproach. The relative solution of water and sewage problems should be taken up for each valley in a scientific practicable way. In so doing it is necessary to bear in mind that the public health demands consideration of the solution of other problems which cost much money. Theoretically the treatment of sewage should not be made so complete that the sanitary benefit derived therefrom is incommensurate with the cost involved.

"*Sterilization Available.*—Fortunately, there is now available by the hypochlorite method a reliable means of sterilizing or disinfecting sewage or water at a small cost. The full significance of this is not yet fully appreciated. It has much bearing on the question of sewage disposal in general, and on the duration method in particular, as related to some conditions."

200. Bacterial Standard of Efficiency.

Wigley, Chester G. Division of Sewage and Water Supplies, State Board of Health, New Jersey. *Engineering Record*, Vol. 65, p. 662–663, 1912.

It would appear that we are fast approaching, if we have not already reached the point, at which the large quantity of sewage from populous districts is compelling a bacterial standard of efficiency rather than one of sight and odor.

With respect to rivers, he concludes that where the river could be used as a water supply any of the methods of purification which would prevent nuisances and greatly reduce the number of pathogenic bacteria would be satisfactory means of disposing of sewage. This might mean simply the settling and sterilization of the sewage or its purification by settling tanks, sprinkling filters and disinfection.

201. Unsolved Problems of Sewage Disposal.

Winslow, C.-E. A. *Trans. Am. Inst. Chem. Eng.*, Vol. 3, p. 385, 1910.

Sewage disposal offers three main problems:

a. A removal of solids.

b. Oxidation of organic matters contained in sewage.

c. Destruction of pathogenic germs.

Though today we can deal successfully with either of these propositions at a cost which is not prohibitive, there arise numerous sub-questions and difficulties.

The author complains, that, though destruction of pathogenic germs by hypochlorite treatment is now an accepted method, failure may result through lack of proper dosing, or uniform admixture of the bleach solution to the sewage, etc.

202. Disinfection at New Bedford, Mass.

SEDGWICK, W. T. Disinfection of the Sewage of the City of New Bedford, Mass. Report to the City of New Bedford, August, 1911.

Professor Sedgwick says: "The real question now before the citizens of New Bedford is this: Shall we infect or shall we protect the waters of the Bay before our doors?—Waters upon which in summer pleasure boats constantly ply, in which children and others are frequently bathing, and over which the breezes frequently blow directly to the city? We are obliged to empty our sewage into the Bay, but we are not obliged thus to empty it without any previous purification. Shall we then simply let it flow in as a stream of unrestricted foulness, or shall we do our best to make it as little objectionable, and especially as little dangerous, to the public health as possible?

"In a word, it is today possible to disinfect during the year perhaps 99% of the entire sewage of a modern city and that at a cost which, although considerable, is by no means prohibitive."

SEWAGE DISPOSAL BY DILUTION.

203. Disposal at Rochester.

KUICHLING, E. Report on Sewage Disposal of the City of Rochester, N. Y. 1910.

Long experience has demonstrated that offensive products of fermentation are not apt to develop when town sewage is diluted by admixture with from 20 to 40 times it volume of well-aërated fresh water. It is also known that after standing 24 hours in a closed vessel the mixture will still contain more than two thirds of its original dissolved oxygen, and would probably contain somewhat more if it had remained in contact with the air; hence, it is evident that after the comparatively small quantity of dissolved oxygen needed for the rapid oxidation of the putrescible organic matter has been abstracted from the water, the *rate* at which the oxygen is reabsorbed from the air is amply sufficient to provide that quantity which is necessary for the complete oxidation of the remaining organic matter without producing offensive conditions.

It must, therefore, be admitted that Nature has provided efficient agencies for maintaining the purity of these bodies of water.

204. Biology of Water.

Kolkwitz, R. Biologie des Trinkwassers, Abwassers und der Vorfluter. (Biology of Water, Sewage and Water-courses.) (In *Handbuch der Hygiene*, by M. Rubner, M. v. Gruber and M. Ficker, Vol. 2, p. 335–386. Leipzig, 1911.

205. Self-Purification.

Hettersdorf, F. Selbstreinigung der Flüsse. (Self-Purification of Rivers.) *Deutsche Vierteljahrsschr. f. öffentl. Gesundheitspfl.* Vol. 40, p. 615–636. Braunschweig, 1908.

206. Philadelphia Report.

Report of the Board of Surveys of the City of Philadelphia, 1911, p. 145.

Natural bodies of water contain bacteria (such as B. racemosus, nitrosomonus and nitrobacter) required to convert organic nitrogen into nitrates through the steps of free ammonia and nitrites; and also the necessary oxygen to maintain these chemical changes to a certain extent. Water has the property of absorbing oxygen from the air, the rate and amount of which is dependent upon the temperature and barometric pressure.

The valuable work of Dr. Adeney, published in the Sixth Appendix of the Fifth Report of the Royal Commission on Sewage Disposal of England, shows that the absorption and rapid diffusion of the atmospheric oxygen by water replenishes the dissolved oxygen, as it is used in the oxidation of putrescent organic matter by the bacteria.

The great cost of purifying the sewage of a large city is such that it is necessary to utilize every natural method without endangering the public health.

207. Limits of Effective Dilution.

Report by the Bureau of Surveys, of the City of Philadelphia, 1911, p. 146.

The difference between offensive and inoffensive pollution of a water course is to a large extent caused by the absence or presence of dissolved oxygen therein; as long as aërobic conditions are maintained the breaking down of complex organic bodies by bacteria will be accomplished inoffensively.

On the other hand, when oxidizable matters are added in such quantities that the oxygen of the water is exhausted, the anaërobic bacteria become active, and the unstable organic matter putrefies, producing foul odors and unsightly appearance.

Sanitary engineers have definitely agreed upon the critical point separating offensive from inoffensive dilution. The limits are shown in the following table:

Cubic feet per second per 1,000 people contributing.

Authority.	Offensive.	Inoffensive.
R. Hering, 1887	Less than 2½	More than 7
F. P. Stearns, 1890	Less than 2	More than 8+
X. H. Goodnough, 1903	Less than 3½	More than 6

208. Summer and Winter Conditions.

Wisner, George M. Report to the Sanitary District of Chicago, October, 1911, p. 5.

From the dilution standpoint, summer conditions are the worst. Observations made at the Thirty-ninth Street pumping station from May 25 to August 9, this year, have shown a variation in temperature from 54 to 74 degrees Fahrenheit, and a variation in content of dissolved oxygen from 13.6 to 8.6 parts per million. In other words, in the study of dilution conditions inside the Sanitary District, summer conditions will govern, since 1,000 cubic feet per minute during summer weather will not effect any more purification than 585 cubic feet per minute in the cooler winter months, so far as the content of dissolved oxygen may effect self-purification. The oxygen is the most active agent in purifying the organic matter in the sewage. In the winter, ice may form on the canal and river, preventing any absorption of oxygen from the air, but this is only for a short period. The water of the canal and the Chicago River is in much better condition during the cold weather than in hot weather.

DIFFERENCES BETWEEN FRESH WATER AND SEA WATER AS REGARDS SEWAGE DISPOSAL.

209. Comparative Merits of Fresh and Salt Water.

Sewage disposal by dilution is considerably modified in some essential features by the differences inherent in the nature of fresh water and of salt water. The sea water is colder and is more liable to maintain separate strata; its higher specific gravity and variances in flow influences miscibility; it absorbs less oxygen and more readily gives off oxygen to the sewage admixture. In the sea water, the oxygen diffuses downward, and the decomposition of sewage-muds is more analytic than in river waters. The planktonial flora is also a different one, and the physiological action of the plankton gives a varying class of chemical reactions.

Freeman, John R., Chief Engineer of the Charles River Dam Committee, which investigated with much thoroughness from an engineering, chemical, and biological viewpoint, these questions arising preparatory to the construction of the Charles River dam, Boston, states (Summary of the 1903 report, p. 76–82):

"I had some predisposition to favor a clean salt-water basin on anything like equal terms, particularly after having observed the pleasure of the children bathing and learning to swim at the Captain's Island Playground, but preliminary study soon led me to conclusions so different from the popular view, as expressed above, that I requested the pathologist, the chemist, and the biologist, each to take up this question from his own field of view, and to make investigations independently of his associates.

"Each of these experts reported that in his opinion the fresh water basin would prove the better.

"The principal results obtained by the chemist, Mr. W. H. Clark, were as follows:

"'1. Conditions being equal, salt water holds somewhat less oxygen in solution than fresh water, and, therefore, volume for volume, fresh water can receive the greater volume of pollution.

"'2. Several lines of incubation experiments were undertaken with mixtures in large, light-stoppered bottles, which were maintained at a constant temperature of 80° C. for five days in order to give very favorable conditions for decomposition. In every case and with all the various percentages of mixtures, it was found that the oxygen disappeared very much more rapidly in the salt water than in the fresh water.

"'Other similar tests were made in which the test bottles were left unstoppered in order that the surface of the water might be open to the air and free to absorb the oxygen from it, but the odors from the mixture with the salt water were in all cases decidedly the worse.

"'Another series of experiments with polluted mud, shaken up with equal quantities of fresh water and salt water, showed that in every case the incubation in sea water exhausted more oxygen than incubation in fresh water, and also exhausted a larger proportion of the oxygen originally present.

"'Comparative bacterial growth was studied in sea water over polluted mud, and in fresh water over the same mud: the greatest anaërobic growths and the greatest exhaustion of oxygen occurred in the sea water.'

"The biologist admittedly expected that a brackish water basin would support the maximum quantity of organic life, and that, therefore, its contents would devour a maximum of pollution on plant food without the production of offensive odors; but soon after beginning he reported insurmountable obstacles to the success of his brackish water plan.

"He reported that through differences in specific gravity, thorough mixture and vertical circulation, with renewal of oxygen by contact with the air, was prevented; that with violent changes of salinity, many of the beneficent low forms of life would be killed off, and that vertical circulation impeded and reaëration being cut off from the lower layers, these lower strata of water were devoid of oxygen, and almost solely populated by the anaërobic or putrefactive bacteria.

"The pathologist, after many bacteriological tests of the quality of the harbor water, found that the introduction of salt water from the harbor would not be needed.

"In conclusion it is stated that beyond any doubt or question, the fresh-water basin will be much better under the circumstances, and that thereby the water at Captain's Island and other points available for bathing can be kept cleaner and more wholesome, even on an incoming tide."

210. Experiments in Scotland.

Murray, Sir John, after spending many years in the Challenger, and other deep-sea expeditions, says nothing could be more striking than the difference to be observed in passing from the examination of a (Scottish) sea loch to a fresh-water loch.

The physical fact, that in salt water the maximum density point is below zero, while in fresh water it lies about 40° above freezing point, determines largely the distribution of temperature and the circulation of water in the two kinds of lochs.

In the sea lochs, dredgings brought up thousands of invertebrate marine animals from a depth of 500 or 600 feet, while fresh-water lochs yielded only five or six dwarfed individuals.

Again, the decomposition of the sulphates of sea water under the influence of decaying organic matter soon renders the deposits at the bottom of the sea loch very foul, which is not the case with the fresh-water lochs; though analysis shows them to contain even more organic matter.

Probably *Microspira desulfuricans* in fresh water, and *Microspira estuarii* in salt water, are chiefly concerned in the reduction of the sulphates in solution.

211. Non-Nitrification of Sewage in Sea Water.

Purvis, J. E., McHattie, S. C. and Fisher, R. H. *Sanitary Record*, Vol. 48, p. 123, 1911.

(1) Sewage incubated with Sea water (10% sewage) with every facility for complete aëration shows no production of nitrites or nitrates after seventy days.

(2) Nitrate was formed when sewage was incubated with distilled water for forty-two days.

(3) In the trial with sea water free ammonia had increased at the end of forty-two days, but it decreased in the sewage and distilled water in the same period.

REASONABLE LIMITS TO OXYGEN EXHAUSTION.

212. Exhaustion of Oxygen.

Fuller, George W. Sewage Disposal, New York, 1912. p. 26.

At its point of origin, sewage is naturally well supplied with oxygen, as it is made up largely of the public water supply.

This question was taken up by the author in considerable detail at the Lawrence Experiment Station in 1894. Briefly, it may be said that in the Lawrence Street sewer, the sewage is ordinarily fresh and contains a substantial proportion of dissolved oxygen. As the sewage passes through a small pipe, some 4,000 feet long, on its way to the experiment station, bacterial activities consume the oxygen.

At Columbus, Ohio, as stated in Mr. Johnson's report of 1905, page 36, dissolved oxygen was ordinarily lacking in the outfall sewer at the testing station from 10 a. m. to about 4 p. m. During the remainder of the day dissolved oxygen was present in varying amounts up to a maximum of about 3 parts per million from about 2 a. m. to 7 a. m.

At Reading, Pa., dissolved oxygen is stated by Mr. E. S. Chase to be practically never lacking in the sewage as it enters the main settling tank, nor indeed at any step in the purification process.

At Plainfield, N. J., Mr. R. S. Lamphear states in an article in the *Engineering Record* of July 1, 1911, that hourly determinations of the quantity of oxygen in the sewage show a range from less than 1 part per million during the afternoon hours to from 6 to 7 parts in the early morning hours.

213. Chicago Experience.

WISNER, GEORGE M. Report to the Sanitary District of Chicago, October, 1911. p. 4.

At the time the act was passed, the knowledge of the requirements for the fish life was practically nothing. Our investigations lead to the conclusion that a nuisance may not occur even though all the fish be dead through the lack of sufficient dissolved oxygen necessary to fish life, but it is evident that there should be from 2½ to 6 parts per million in order that the fish may live, some fish being able to live in water with less oxygen than others. So if fish life is to be maintained, the dissolved oxygen in the water should not be allowed to be less than 2½ parts per million. The canal flow, during the three summer months of 1911 has contained less than this amount through practically its entire length. Apparently a minor, intermittent fish life, such as so-called shiners or small minnows, does exist at times, but these are soon suffocated and killed by the continued lack of oxygen during the summer months, the amount of oxygen content in the water increasing during the winter months.

Ibid., p. 3.

The dilution established by the Sanitary District Act of 1889 is that there shall be a flow of at least 3.3 cubic feet per second for every 1,000 people sewering into the canal. The present flow is practically that minimum figure. Later observations have confirmed the ratio in a general way, the established feeling being that from three to seven cubic feet per second flow is required per 1,000 people sewering in. At present during the summer weather, the oxygen in the water of the canal is frequently exhausted at Lockport, and continues that way as far as 10 to 15 miles above Lockport.

214. Quantities of Dissolved Nitrogen.

Quantities of Dissolved Oxygen in Water Saturated with Air at the Temperatures Given (In parts per million by weight). *In* Standard Methods of Water Analysis, published by the Am. Public Health Association, 1905.

Temperature C.	Oxygen.	Temperature C.	Oxygen.
0	14.70	16	9.94
1	14.28	17	9.75
2	13.88	18	9.56
3	13.50	19	9.37
4	13.14	20	9.19
5	12.80	21	9.01
6	12.47	22	8.84
7	12.16	23	8.67
8	11.86	24	8.51
9	11.58	25	8.35
10	11.31	26	8.19
11	11.05	27	8.03
12	10.80	28	7.88
13	10.57	29	7.74
14	10.35	30	7.60
15	10.14		

SOME STATEMENTS ON OXYGEN EXHAUSTION IN SEWAGE DISPOSAL.

215. Experience in Chicago.

WISNER, GEORGE M., Chief Engineer of the Sanitary District. Report on Sewage Disposal Made to the Board of Trustees of the Sanitary District of Chicago, October 12, 1911. p. 17.

So long as the amount of putrescible matter is not too great, plant life and natural processes will oxidize it without nuisance, but should there be an overload continued for any length of time, the efficiency drops off, and a nuisance results. Where the oxygen content of the flowing stream is lowered to the limit, fish must depart to purer water or suffocate. Continued conditions of lack of oxygen are not essential. A few hours or a day suffice to destroy fish life.

216.

Ibid., p. 5.

In mixtures of sewage and water we have found that the consumption of dissolved oxygen proceeds much faster at the start and at a diminishing rate, until it is either all exhausted in a very putrescible mixture or reaches the minimum of a more stable condition. The Marseilles dam aërates the liquid very thoroughly and the oxygen is greedily absorbed.

217.

Ibid., p. 7.

From the standpoint of condition, table 2 gives the best information, showing a highly putrescible mixture from May to September, with the oxygen practically exhausted. The passage through the turbines causes a slight increase in the content of oxygen. Whenever water is passed over the spillway marked aëration ensues. Under average conditions this is sufficient to raise the oxygen content below the power house or two or more parts per million.

Record of Dissolved Oxygen and Putrescibility at the Power House of the Sanitary District, Lockport.

1911.	Temperature of water.	Dissolved oxygen.		Putrescibility.
Date.	Centigrade.	Parts per million.	Per cent. saturation.	Relative stability number.
March 21	4.5	7.5	58	84
	4.5	3.6	28	87
30	5.0	4.7	37	75
	5.0	4.7	37	44
April 6	4.0	5.4	41	80
	4.0	4.1	31	75
13	8.5	4.3	37	75
	9.0	4.3	37	75
27	12.0	0.6	6	60
	12.0	0.9	8	78
May 4	11.3	2.4	22	71
	11.3	1.6	15	10
10	15.0	0.5	5	32
18	16.0	0.3	4	32
	16.0	0.3	4	25
23	15.0	0.6	6	80
June 1	18.0	0.2	2	18
	18.3	0.2	2	18
16	18.8	0.04	0.4	7
	18.8	0.04	0.4	7
22	22.4	0.0	0	9
	22.8	0.0	0	8
29	21.0	....	....	9
30	21.5	0.1	1	9
July 6	23.0	0.0	0	15

1911.	Temperature of water.	Dissolved oxygen.		Putrescibility.
Date.	Centigrade.	Parts per million.	Per cent. saturatin.	Relative stability number.
	23.0	0.0	0	10
July 13	23.8	0.0	0	5
	23.7	0.0	0	5
19	22.8	0.0	0	5
	....	0.0	0	....
19	22.2	0.0	0	4
	....	0.0	....	....
20	21.1	0.0	0	6
	....	0.0	0	....
28	18.9	0.0	0	5
Aug. 3	17.4	0.2	2	9
	17.3	0.2	2	8
10	20.9	0.3	3	24
	20.8	0.3	3	20
17	23.0	0.0	0	6
	23.2	0.0	0	4
24	20.1	0.0	0	6
	20.0	0.0	0	6
30	20.0	0.0	0	9
	19.9	0.0	0	9
Sept. 14	20.0	0.0	0	9
	19.7	0.0	0	9
21	20.1	0.0	0	8
	20.1	0.0	0	8
28	19.0	0.1	1	9
	18.9	0.1	1	8

218.

Ibid., p. 17.

The present scheme of dilution has not proved a failure; on the contrary, it has been a great success. But it is essential that the future be watched and conditions as they exist closely studied. Careful study shows that immediate action is necessary to prevent the diluting water from being overloaded with manufacturing wastes, as the water available for dilution is not sufficient to properly dilute the sewage wastes coming from the large manufacturing concerns. Large quantities of sediment are yearly deposited in the beds of the

Calumet, Illinois and Des Plaines rivers. Mill dams and other destructions in the rivers hold back settled or settling material. The low velocity through the wider stretches of the rivers and the so-called "lakes" permits sedimentation. Sedimentation means the accumulation of fresh or partly digested organic matter which will continue to ferment. This uses up oxygen which should be available for the sewage proper and not to oxidize old accumulations of sludge.

219.

Ibid., p. 8.

The most satisfactory tests we have found to be the field for tests for dissolved oxygen, supplemented by the putrescibility test. The content of dissolved oxygen gives the present condition of the liquid, a concentration factor so to speak, while the putrescibility test is an indication of the stability of the mixture, that is, it shows the rate at which the dissolved oxygen is undergoing exhaustion. A mixture may be 50% saturated with dissolved oxygen and yet be highly putrescible. Both factors must be studied side by side, in order to gauge the condition of the mixture of sewage and water and the progress of self-purification.

220.

Ibid., p. 76.

The present scheme of sewage disposal by dilution has been a pronounced success. When the canal was designed it was not intended that the crude manufacturing wastes should be deposited therein, as they have been and are now being. Practically nothing was known of the absorption of oxygen from water by organic sludges that deposit on the bottom of the river and canal.

221. Protection of River and Harbor Waters.

WINSLOW, C.-E. A. Protection of River and Harbor Waters from Municipal Wastes, with Special References to the Conditions in New York. In *Am. Museum of Natural History Guide Leaflet*, Series No. 32, April, 1911.

The influence of sewage on the water in New York Bay is clearly reflected by the following figures on variations in oxygen contents.

	Per Cent. of Saturation.	
	High.	Low.
Hellgate	92	80
Harlem River	43	27

222. Dissolved Oxygen in New York Harbor.

Oxygen dissolved in the Waters of New York Harbor and Vicinity. Report by the Metropolitan Sewage Commission, New York, April 30, 1910.

The figures are averages of the results from large numbers of analyses of samples collected from June 17 to October 5, 1909.

Location of Samples.	Ebb currents.		Flood currents.	
	Cubic centimeters per liter.	Per cent. of saturation.	Cubic centimeters per liter.	Per cent. of saturation.
Upper Bay	36.0	64	4.91	78
Hudson River, below Spuyten Duyvil	3.67	66	4.63	76
Hudson River, above Spuyten Duyvil	5.13	83	5.01	84
East River, below Hellgate	3.46	60	4.03	69
East River, Hellgate to Long Island Sound	5.38	92	4.66	80
Long Island Sound, near Throgs Neck	5.90	100	5.78	98
Harlem River	3.28	56	3.21	55
Kill van Kull	4.49	78	4.76	82
Newark Bay	4.21	74	4.41	78
Passaic River at Newark	0.30	5	0.42	7
Arthur Kill	4.31	73	5.61	100
Narrows	4.16	74	5.18	92
Gravesend Bay	....	..	5.00	90
Lower Bay	5.29	95	5.56	100
Rockaway Inlet	5.10	93	6.14	100
Jamaica Bay	4.06	73	4.26	81
Atlantic Ocean, ten miles off Long Branch	....	..	6.05	100
Gowanus Canal	0.00	0	....	....
Newtown Creek	....	..	0.00	0
Wallabout Canal	0.30	6	....	....

NOTE.—In calculating the above averages all the samples collected in the various sections were included, except that in the cases of Gravesend and Jamaica Bays, those samples collected near sewer outlets were not used.

223. Need for Increased Dilution at Chicago.

Demand for Increased Volume of Water for Sewage Dilution in Chicago. *Municipal Journal*, Vol. 32, p. 451, 1912.

The City and Sanitary District have requested the Secretary of War to be allowed to take 10,000 cubic feet of water per second from Lake Michigan into the drainage canal for dilution. The District now has the right to take 4,167 feet a second. Unless the request is granted it is claimed that all fish in the Illinois River will be killed. Approximately 46,000,000 pounds of fish annually are sold from the stream. Mr. George M. Wisner, Chief Engineer

of the Sanitary District, states that unless the request is granted, the city will be compelled to expend between $40,000,000 and $60,000,000 for adequate facilities to dispose of sewage.

PUTRESCIBILITY AND STABILITY TESTS.

224. Abstract of Experience.

If sewage could receive from time to time throughout its entire course sufficient air to keep some oxygen present at all times, anaërobic decomposition would not set in and so-called putrefaction with attendant bad odors would not exist.

This dependence of inoffensive sewage disposal on oxidation had been recognized at an early date.

Chemists, therefore, sought in laboratory methods for measuring the total oxygen requirements of a sewage.

In America the oxygen consumed is determined by adding sulphuric acid and a solution of potassium permanganate to the liquid and heating to 212° F. for two, five or ten minutes. In England, the temperature at which the liquid is allowed to stand, is usually 80° F., and the results are observed after three minutes and again after four hours.

On page 366 of the Massachusetts "State Board of Health Report for 1905," comparisons of two-minute, five-minute and thirty-minute boiling of samples with permanganate, or "oxygen consumed" results, are given. In this work, oxygen consumed by both two- and five-minute boiling was determined on over six hundred samples of various kinds of water, sewage and effluents. The results by the two-minute method averaged for each class of water between 70% and 80% as high as the results by the five-minute method.

Here the absolute oxygen consumed is sought, indicating the needed amount of oxygen from a chemical in the laboratory for the complete moist combustion of all organic constituents.

Efforts to secure the oxygen-consuming power as actually needed to provide for the proper development of bacteria have resulted in the test proposed by the Royal Sewage Commission which determines putrescibility by the amount of atmospheric oxygen absorbed in sewage.

In this test, atmospheric oxygen is introduced into the effluent by means of aëration. The amount of free oxygen the liquid then contains is determined, and the amount taken up by the organic matter is shown by the amount of free oxygen remaining in the liquid at the end of the given period.

The report, 1908, of the Royal Sewage Commission states:

"According to our present knowledge, an effluent can best be judged by ascertaining, first, the amount of suspended solids which it contains, and, second, the rate at which the effluent, after the removal of the suspended solids, takes up oxygen from water.

"In applying this test, it is important that the suspended solids should be removed and estimated separately.

"For the guidance of local authorities we may provisionally state that an effluent would generally be satisfactory if it complied with the following conditions:

"(1) That it should not contain more than 3 parts per 100,000 of suspended matter; and

"(2) That, after being filtered through filter paper, it should not absorb more than

"(a) 0.5 part by weight per 100,000 of dissolved or atmospheric oxygen in 24 hours;

"(b) 1.0 part by weight per 100,000 of dissolved or atmospheric oxygen in 48 hours; or

"(c) 1.5 parts by weight per 100,000 of dissolved or atmospheric oxygen in 5 days."

The most efficient methods for determining putrescibility and stability have been devised by Prof. E. B. Phelps.

His test for relative stability of a sewage, now universally accepted, rests upon the following reasoning.

Sewage contains a complex mixture of organic substances, and practically all this organic matter is oxidizable through bacterial activities.

In the case of a sewage, where dissolved oxygen has not at any time been absent, and to that limit, aërobic, inoffensive oxidation takes place.

Beyond that limit, when the dissolved oxygen has been exhausted, the anaërobic activities upon any remaining organic matter cause putrefaction and bad odors.

Stability means that state of a treated sewage in which no putrefaction will occur, notwithstanding the fact that no dissolved oxygen is present in the sample.

Such a state of stability can result only from oxidation having already been carried through on aërobic lines to the very finish, so that there really remains no chance for work left for putrefying anaërobic bacteria which thrive in the absence of dissolved oxygen.

Relative Stability.

When the oxygen found dissolved in a sample of sewage or a mixture of water and sewage has been consumed and putrefaction begins to set in, then the ratio of that oxygen to the amount of oxygen which would have insured perfect stability is termed relative stability; a sewage with only 40% of the total oxygen required for stability has a relative stability of 40.

In practical sewage disposal, relative stability is all that is needed, because it is the meaning of sewage disposal by dilution: that in the river courses with their large oxygen contents, bacterial activities will, on aërobic lines, carry on and finish the oxidation to the stability goal.

When a sample of sewage in a stoppered bottle keeps for 3 weeks without putrefying, its stability is perfect; it will keep for any further length of time.

When keeping without putrefaction for days.	Its relative stability equals.
20 days	99
10 "	90
9 "	87
8 "	84
7 "	80
6 "	75
5 "	68
4 "	60
3 "	50
2 "	37
1 day	21

These figures have been worked out by Professor Phelps in a large series of experiments and calculations. He states (Water Supply Paper 229, U. S. Geological Survey):

"An effluent of relative stability is not stable in the absolute sense, because its available oxygen is less than the oyxgen required for equilibrium; but, of two such effluents, that one is obviously the better which contains the greater amount of available oxygen in proportion to its required oxygen. This relative stability, as will be shown, can be measured by the time required to reach the anaërobic stage. The term stability without qualification is employed in this paper to describe that condition in which the available oxygen exceeds the required oxygen, and the term relative stability is used to indicate the character of the effluent in the sense suggested. A perfectly stable effluent, therefore, has a relative stability of 100%."

This method (Incubation Test) consists in adding a small amount of methylene blue or methylene green dissolved in water to the effluent or sewage, in a tightly stoppered bottle and noting the number of days for the color to be discharged. The time required for decolorization depends as upon the temperature, being twice as long at 70° F. as at 98°.

The colors added are broken down into colorless derivatives by various substances formed, especially hydrogen sulphide, during putrefaction.

More recently a delicate method on the lines of aëration, as was proposed by the Royal Sewage Commission has been devised, and described in the Report on New York Harbor Waters, by Col. W. M. Black, U. S. A., and Prof. E. B. Phelps, March 23, 1911, page 66. Suitable mixtures of the sewage in question with oxygen-saturated water are made and the total amount of oxygen in the mixture determined immediately. The sample is then stored in a tight bottle for a suitable period of time and a redetermination of the amount of dissolved oxygen present is made. The rate at which the oxygen disappears under these conditions gives us an index of the oxidizability of the organic matter and a more direct measure of the probable effect upon the stream then is given in the methylene blue method.

225. Determination of Oxygen Consumed.

Hoover, C. B. A Method of Determining the Dissolved Oxygen Consumed by Sewage and Sewage Effluents. *Engineering News*, Vol. 65, p. 311, 1911.

The method used at Columbus, Ohio, consists in making a suitable dilution in tap water, and determining the dissolved oxygen of the mixture before and after incubation for 24 hours. The difference is referred to the original sample as "Oxygen dissolved consumed."

Compared with the usual oxygen dissolved from permanganate it is shown to be more truly indicative of the work of the filter.

226. The Quality of Effluents in Relation to Standards.

Fowler, G. J. *Roy. San. Inst. Jour.* Vol. 30, p. 513–532. London, 1910.

227. Standard Methods.

Standard Methods for the Examination of Water and Sewage. American Public Health Association, New York, 1912. 144 p.

STERILIZATION OF SEWAGE.

228.

Report of the Bureau of Surveys of the City of Philadelphia, on the important work at the Spring Garden Experiment Station, carried on under supervision of Messrs. G. E. Datesman, W. L. Stevenson and others, and in coöperation with Mr. Rudolph Hering, C. E., and other noted experts. Philadelphia, 1910. Partial report upon the Comprehensive Plan for the Collection, Purification and Disposal of the Sewage of the Entire City, Philadelphia, 1911.

Page 127, *Disinfection of Sewage.*—Experiments were conducted upon sewage which had been subjected to three different degrees of preliminary treatment, *i. e.*, fine mesh screening, sedimentation, and sedimentation subsequent to fine mesh screening. These are arranged in the order of their efficiency in removing suspended solids and consequently of oxidizable matter.

The amount of calcium hypochlorite (the material used in all experiments) necessary to disinfect sewage is directly proportional to the amount of oxidizable matter contained therein. It is expected and the experiments showed that the screened sewage required the largest quantity of disinfectant and screened and settled sewage the least.

As the strength of sewage has a daily and hourly fluctuation, and amount of calcium hypochlorite adequate for disinfection at one time would be insufficient at times of greater strength, and uneconomical at times of lesser strength; and as disinfection to be depended upon must be uniform in its results, the amount added must be that needed to meet the maximum requirements.

Period of Contact.—In the large scale experiments only one period of contact was studied, namely, two hours nominal flow through the tank. The actual flow through the tank was in less than two hours as determined by the passage of dyes.

229. Résumé of Results in Sewage Disinfection Work.

Ibid, p. 128.

The results of disinfection are shown in Table No. 43, in which two conditions are shown: First, such an amount of disinfectant added that during an epidemic considerable assurance would be felt that other municipalities lower down the river were adequately protected; secondly, such an amount added that would destroy over 95% of the B. coli, at a moderate cost. With the after-effect of dilution and oxidation this would clearly indicate efficient disinfection from a practical standpoint.

It will be seen that in the first case 12 parts per million available chlorine (approximately 300 pounds of dry bleaching powder per million gallons of sewage) effected almost complete disinfection, there being residual chlorine present in considerable quantity after two hours. Under the second or ordinary condition, adequate disinfection was accomplished with less than one half the amount.

Sewage which had been passed through the fine mesh screen only and treated with about 150 pounds of dry bleach per million gallons, or when screened and settled and treated with 105 pounds of bleach, was economically disinfected.

230.

Ibid., p. 129, Table 43.

Average Results of the Disinfection of Sewage from which Suspended Solids, at least larger than 1 mm., have been Removed by Preparatory Treatment (Based upon 112 Samples).

Sewage used in Experiments.	Available chlorine added.	Residual chlorine in effluent.	Total number of bacteria per cc. on gelatine at 20° C. in 48 hours.			B. coli. per cc. as per Jackson's presumptive test.		
			Initial.	Final.	Per cent. removed.	Initial.	Final.	Per cent. removed.
Fine Mesh* Screen†	12.4	4.7	2,470,000	337	99.99	121,000	20	99.98
	6.0	0.5	2,060,000	181,000	91.21	149,000	7,470	95.48
Effluent of horizontal flow, Sedimentation Tank No. 13 (influent crude sewage)	11.9	3.4	2,450,000	350	99.99	143,000	10	99.99
	5.4	0.7	760,000	31,000	95.92	67,000	745	98.89
Effluent of horizontal flow, Sedimentation Tank No. 21 (influent screened sewage)	12.0	3.1	2,130,000	310	99.99	86,000	20	99.98
	4.2	1.1	660,000	22,500	96.59	317,000	1,350	99.57

* Approximately 1:25,000 (300 parts Bleach per 1,000,000 gallons).

† Approximately 1:50,000 (150 parts Bleach per 1,000,000 gallons).

231. Laboratory Experiments on Rate of Exhaustion.

Ibid., p. 133.

Fresh sewage from the intercepting sewer and passed through the fine mesh screen was equally divided among six bottles and to each a different quantity of strong calcium hypochlorite solution added in amount required to yield the parts per million shown in table No. 47. At the end of the times indicated in the table the bottle was agitated and a measured portion withdrawn for the determination of residual chlorine, also when the residual chlorine was exhausted, or if not, at the end of the test, 250 cc. were taken and as soon as the residual chlorine had been determined, an amount of sterile sodium thiosulphite, just sufficient to neutralize the residual chlorine added and a "methylene blue" sample placed in the incubator.

Table No. 47.

Chlorine absorption when constant volumes of sewage are treated with different quantities of hypochlorite of lime solution for different lengths of time.

Screened Sewage March 24, 1910.

Available chlorine added.	Parts per million residual chlorine, elapsed time in hours.									Relative stability with methylene blue at 20 degrees C.
	0.5	1.0	1.5	2.0	3.0	4.0	5.0	6.0	7.0	
5.0	0	0	0	0	0	0	0	0	0	0.47
7.5	2.0	0	0	0	0	0	0	0	0	0.59
10.0	4.0	2.0	1.5	1.0	0	0	0	0	0	0.79
15.0		6.0	6.0	6.0	5.0	5.0	4.0	4.5	4.5	1.00
20.0		7.0		6.5	4.0	3.0	3.0	2.5	2.0	0.96
25.0		8.0		6.5	5.0	4.0	4.0	3.5	3.0	1.00

232.

Ibid., p. 135, Table 48. Relation Between Time of Contact and Efficiency of Disinfection with Calcium Hypochlorite.

Chemical Analysis of Sewage.

End.	Parts per million.			Elapsed time in minutes.								
				10			20			30		
	Total suspended solids.	Oxygen consumed.	Available chlorine added.	Residual chlorine.	Per cent. reduction 20 degrees.	Relative stability.	Residual chlorine.	Per cent. reduction 20 degrees.	Relative stability.	Residual chlorine.	Per cent. reduction 20 degrees.	Relative stability.
Screened	120	58.4	* 5.0	0.7	99.88	.45	1.4	99.81	.50	0.7	99.97	.50
			† 7.5	3.6	99.90	.53	2.8	99.94	.53	2.8	99.92	.71
			‡ 10.0	7.7	99.87	.47	4.3	99.89	.62	3.5	99.95	.90

233.

Ibid., p. 143. Disinfected Sewage Compared with the Effluent from Oxidizing Processes.

On March 23, 1910, screened sewage was being disinfected with 6.9 parts per million available chlorine; analysis showed that there was no residual chlorine present in the effluent, and the disinfectant had destroyed 97.1% of the bacteria. A sample of the effluent was added to tap water to make nine dilutions, ranging from one part effluent to two parts tap water up to one to ten. These were incubated at 20° C. with methylene blue, and were still stable at the end of ten days (except the one to two dilution).

During April the relative stability of the screened and disinfected sewage was determined the same as the effluents from sprinkling filters, and the comparative data is shown in the following table:

Average Relative Stability During April, 1910 (Sunday samples excluded).

Screened and disinfected sewage:	Relative stability
Undiluted	.31
Diluted with equal volume of tap water	.34
Effluent of sprinkling filters operated at 2½ million gallons per acre per day:	
No. 20–4, 7 ft. of 1-in. to 3-in. trap	.64
No. 20–5, 4 ft. of ½-in. to 3-in. trap	.28

From this comparison it is seen that screened and disinfected sewage was more stable than a poor sprinkling filter effluent, although not equal to that from an efficient one.

* Approximately 125 lbs. per 1,000,000 gallons.
† Approximately 190 lbs. per 1,000,000 gallons.
‡ Approximately 250 lbs. per 1,000,000 gallons.

It was discussed, but not determined, whether this result was accomplished by the chemical oxidation, by the calcium hypochlorite of the putrescent matter; or by the retarding of putrefaction by the disinfecting action of the bleach until the oxidation of the putrescible matter was brought about biologically.

234.

Ibid., p. 149. Disposal of Disinfected Sewage by Dilution.

It was not expected that after the addition of the screened and disinfected sewage to the river water flowing through the dilution tank, that its chemical or bacteriological analysis would indicate a potable water, and a special standard was, therefore, required to determine the condition of the water after the addition of the polluting sewage. The criterion adopted was that, although not potable, the water should continue to improve chemically and bacterially (as relating to pathogenic germs); that the dissolved oxygen should not be depleted below 50% saturation, the limit set by the English Royal Commission for major fish life; that it should always be stable as indicated by the methylene blue test, and inoffensive to sight and smell.

This criterion was in accordance with the definition of a perfect effluent as proposed by Mr. J. D. Watson, engineer of the Birmingham, etc., Drainage Board. "A perfect effluent is not an ideal one; the ideal is to obtain by natural means an effluent which will not putrefy, and which will continue to improve when it is discharged into a stream."

Dates 1909–1910.	Daily average temperature.		Ratio sewage to river water 1 to —.	Hours flow in tank.	Source of Sewage—Station number—See below.	Per cent. saturation. Dissolved oxygen.		
	Air.	Water.				River water.	Influent end.	Effluent end.
Sept. 27 to Oct. 7..	21	20	20	21.5	42	60.2	44.3	35.5
Oct. 18 " Oct. 29..	19	14	20	21.5	43	65.1	58.9	60.1
Oct. 29 " Nov. 25..	19	12	30	16.3	42	67.6	70.8	68.2
Nov. 5 " Dec. 13..	13	7	40	12.0	42	81.2	89.6	85.3
Jan. 15 " Jan. 24..	12	4	20	24.0	42	93.0	90.2	89.5
Jan. 25 " Feb. 1..	11	30	20	24.0	41	97.3	86.8	90.4
Feb. 2 " Feb. 6..	11	3	20	24.0	41	96.8	92.2	90.9
Feb. 7 " Feb. 17..	11	3	15	24.0	41	91.3	89.1	88.8
Feb. 18 " Mar. 13..	14	5	10	24.0	41	93.2	92.1	89.5
Mar. 14 " Mar. 31..	18	10	7	33.0	41	77.0	59.5	56.6
April 1 " April 30..	13	17	7	33.0	41	82.2	57.1	52.5

41 equals fine screened sewage disinfected; 42 equals screened and settled

235.

Ibid., p. 152. Conclusions on Dilution of Disinfected Sewage.

Having in mind the conditions set forth, and using the standard determined upon, the experiments showed that if fresh, crude sewage was passed through a fine mesh screen to remove its larger solids or satisfactorily settled, and then disinfected with 6 parts per million available chlorine and was added to river water in amounts up to one tenth of the volume of the river water, its purification was accomplished without offense to sight or smell and the depletion of the dissolved oxygen of the river water was not carried below 50% saturation.

MODE OF STERILIZING SEWAGE AND COST.

236. Mode of Sterilizing Sewage.

Fuller and Hering, New York City. Report of the Advisory Sewage Disposal Commission of the City of New Brunswick, March 6, 1911.

The chloride of lime will be applied at a rate of about 75 to 150 lbs. per million gallons. Its sterilizing effect is substantial and satisfactory, as is well known through numerous investigations at Boston, Mass., Red Bank, N. J., and Baltimore, Md., as set out in the paper prepared by Prof. E. B. Phelps and which appeared as Paper No. 229, of the publications of the United States Geological Survey. The most distinctive feature of the design for this plant is in the arrangement whereby the proper volume of this solution will be automatically adjusted to meet the varying flows coming from the sewer. It is expected that there will be obtained regularly a bacterial removal from 98 to 99% or more.

In order to allow the hypochlorite of lime to act upon the settled sewage, there are provided mixing and detention chambers built of brick with concrete foundations, covered by a building and open for inspection. This chamber is just the opposite of a settling chamber and its purpose is to thoroughly mix the chemical with the settled sewage and have the latter flow at a velocity such that there will be substantially no deposition in the channels. The period of detention will ordinarily be about ten minutes after the application of the sterilizing chemical and before the treated sewage leaves the plant on its way to the river.

After this plant is once in good working order, it should be a very easy and simple one to operate. It will be necessary twice a day or so to prepare solutions of the chemical and once or twice a week to remove sludge from the digestion chambers of the settling basin.

237. Dosing Apparatus for Sewage.

Hansen, A. E., *Engineering Record*, Vol. 65, p. 388–390, 1912.

For reliably sterilizing small volumes of sewage without much call for attention by a skilled operator, the hypochlorite equipment installed by Mr. A. E.

Hansen of the firm of Lederle and Provost, New York City, in the sewage disposal plant for the Hebrew Sheltering Guardian Society at Pleasantville, N. Y., deserves notice.

There are no moving parts in this dosing device, a description of which, with drawing is given in the *Engineering Record.*

238. Disinfection at New Bedford.

PHELPS, E. B. Report on Disinfection of the Sewage of the City of New Bedford, Mass., August, 1911.

The addition of small quantities of lime together with the bleach has been shown to increase its efficiency and correspondingly reduce the cost. Actual experiment is still necessary to determine the exact quantities of both the bleach and the lime required in any given case, since different sewages react. differently under similar treatments. The treated sewage must then be held for a period of about fifteen minutes for the completion of the disinfection This storage should be obtained in a tank which will prevent sedimentation as far as possible.

The proper admixture of disinfectant is obtained by distributing it as well as possible in a horizontal cross section and then by passing the flowing sewage over the under horizontal baffles, securing proper mixture in a vertical plane. Storage without sedimentation can be obtained in a specially designed tank, sketches of which have been submitted to you. This is a continuous flow tank in which sedimentation is prevented by the upward flow of the liquid.

239. Disinfecting Sewage at Redbank, N. J.

PHELPS, E. B. Water Supply Paper 229, U. S. Geological Survey. Washington, 1909.

The automatic dosing of the sewage (regulating the amount of chloride of lime solution, that mixes with the sewage as it is flowing through the inlet main into the sterilization tank) is effected by having the small feeding tank, containing the bleach solution, suspended on one end of a long lever, the other end of which is connected with a large float in the sterilization tank. As this flow rises with increased flow, the small tank naturally goes down, and consequently, an increased amount of solution can flow into it from a constant level store tank, with which it is connected. By this increased head over the orifice of the small feeding tank more chloride of lime solution will be discharged into the crude sewage.

240. Sewage Disinfection in Atlantic City, N. J.

Sewage Disinfection in Atlantic City, Bridgeton, and Rahway, N. J. Thirty-fifth Annual Report of the Board of Health of the State of New Jersey, 1911.

The hypochlorite disinfection plant for the treatment of the sewage of the Chelsea district, of Atlantic City, is situated at the end of Raleigh Avenue near the Thoroughfare, and was put in operation about August 10, 1911.

The plant consists of two underground retention chambers each about 6 feet by 8 feet and 10 feet deep, separated by a wall in which there is a rectangular orifice which can be regulated by a gate. One tank receives the sewage and the other is connected by an outfall pipe with tide-water in the Thoroughfare. The hypochlorite solution is mixed in a concrete tank and run into one of two storage tanks, connected with a dosing box, in which a constant level is maintained by a float-valve. The orifice between the retention chambers is so throttled that there is a slight excess of head in the tank on the sewer side at times of minimum flow through the orifice, and a floating discharge pipe in the dosing box is so controlled through differential gears by floats on both sides of the orifice, that the flow of bleach solution is cut off when the tidal head is in excess, and varies with the excess head on the other side of the orifice. The effluent is discharged through a 16-inch pipe below low water a few feet from the bank.

241. Bridgeton.

The Bridgeton sewage disposal plant consists of two hypochlorite disinfection plants, one on each side of the Cohansey Creek.

At the Glass Street plant, sanitary sewage flows by gravity to an ejector well, from which it is raised by two Blaisdell ejectors to the sedimentation beds.

The sedimentation basins, two in number, are each 100 feet by 12 feet and 7 feet deep to the flow line. The floors are pitched to sludge gates, by means of which the basins can be drained to the suction well of a triplex plunger pump, driven by a gasoline engine.

From the sedimentation basins, sewage flows over mixing weirs, at which the hypochlorite is added to the disinfection tanks. These are two in number, each 50 feet by 6 feet and 7 feet deep to the water line, and the floors pitch to sludge gates draining to the well of the triplex pump.

There are two hypochlorite mixing tanks, each 4 feet by 3 feet, by 3 feet 6 inches.

The mixing tanks, the two air compressors for operating the ejectors, the triplex pump, and the gasoline pump are neatly housed in a pressed brick building.

The Water Street plant is quite similar to the other, though smaller and there are no gates.

242. Rahway.

At the New Jersey State Reformatory, at Rahway, N. J., has been installed a new sterilization plant. The sewage enters a screening chamber. From this chamber the flow passes into a Dortmund tank 10 feet square and 9 feet deep, and hence into one of two detention tanks 19 feet by 4 feet 6 inches and 4 feet deep at inlet end and 6 feet deep at outlet end. Between the Dortmund and detention tanks the sewage receives a dose of chloride of lime solution.

Provision is made to draw off the accumulated sludge into a sump from which it is pumped out. The sewage after leaving the detention tank flows down the 10-inch pipe to the tidal tank located on the river bank.

This tank is 20 feet square and 5 feet deep to the flow line, and it discharges the sewage only at ebb tide.

243. Plans for Joint Sewage Disposal Works.

Plans for Joint Sewage Disposal Works for Orange, Montclair and East Orange, N. J., calculated on an average daily quantity of 17,000,000 gallons (to be reached in 1915) including course screen, grit chambers, Imhoff settling tanks, sludge—drying beds, sprinkling filters and disinfection with chloride of lime have been prepared by Mr. Rudolph Hering, C. E.

A Venturi meter will regulate the effluents and as the flow through the meter increases or decreases, the difference in pressure in the two pressure chambers of the meter will regulate the ingress of the bleach solution accordingly.

244. Cost of Operating Disinfecting Plant.

Phelps, E. B. Total Cost of Operating Disinfecting Plant: Based upon a Plant having a capacity of 5,000,000 gallons per day. *Jour. of the Assn. of Eng. Societies,* Vol. 46, p. 31, Boston, 1911.

Av. Cl. parts per million.	Bleach pounds per million gallons (Approx.).	Time of contact, hours.	Cost per million gallons.					
			Fixed.			Operating.		
			Storage tanks.	Other fixed charges.	Bleaching powder.	Labor.	Power.	Total.
1	25	5.0	$0.10	$0.02	$0.30	$0.10	....	$0.52
2	50	2.5	0.05	0.04	0.60	0.10	....	0.79
3	75	1.6	0.04	0.05	0.90	0.10	$0.02	1.11
4	100	1.2	0.03	0.07	1.20	0.10	0.02	1.42
5	125	0.8	0.03	0.08	1.50	0.10	0.03	1.74
10	250	0.5	0.02	0.16	3.00	0.15	0.06	3.39
15	375	0.5	0.02	0.24	4.50	0.20	0.09	5.05

245. Cost of Emscher Tank.

Wisner, George M. From report to the Sanitary District of Chicago, October, 1911. p. 42.

Although the first cost of the Emscher type of tank is considerably higher than that of the others, the amount of sludge removed to be handled is much less, and it is our opinion that this type of tank is the most suitable and inexpensive in the long run, when the cost of handling the removed sludge is taken

into consideration. It also causes less of a local nuisance. For the purpose of this report, therefore, the Emscher tank has been taken as the desired standard in estimating the relative costs for the various sized plants that are considered:

Plant to handle population.	Cost per capita.
10,000 to 100,000	$1.50
100,000 to 500,000	1.40

245. Construction Cost of Sewage Purification Works.

BELCHER, D. M. *Engineering News*, Vol. 67, p. 680–681, 1912.

This paper gives a classification of the units of plant entering into the composition of the sewage disposal plant at Washington, Pa., and prices, according to types and capacity.

SUSPENDED MATTERS IN SEWAGE AND SLUDGE.

247. Suspended Solids in Sewage.

From the report of the Board of Surveys, of the City of Philadelphia, 1911.

The dissolved matters are most easily acted upon by bacteria. The case with which purification is effected increases as the sizes of the solids decrease. Mr. Emil Kuichling in his Report on Disposal of the Sewage of Rochester, 1907, states that double the dilution is required by the "suspended solids" as by the "dissolved matters."

If, therefore, the suspended solids, or even part of them, are removed before the sewage is discharged into a river, the amount of such treated sewage that can be added without producing an offensive condition would be much greater than of crude sewage.

248. Suspended Matter in Sewage in Relation to Disinfection.

PHELPS, E. B. Report to the City of New Bedford, August, 1911.

Owing to the rapidity of the disinfecting action and the comparative slowness with which the hypochlorite attacks suspended organic matter, that is organic matter which is not dissolved, the decreased cost of disinfection which follows any clarification process is quite slight and not at all commensurate with the cost of such clarification. The second conceivable difficulty in the treatment of crude sewage by disinfection is due to the presence of solid particles of such a size that penetration by the germicide is difficult or impossible. This feature is more characteristic of the sewage of a small community than that of a large city. In the case of the Boston sewage a comparatively small amount of material is removed by screens of half-inch opening and it has been found that the sewage thus screened is in proper condition for immediate disinfection without further treatment. In fact, most of the experience upon

which our present practice is based has been derived from work upon the sewage of Boston. We anticipate that the sewage of New Bedford after passing through the long trunk sewer which has been provided in the plans will approximate in character that of Boston, and that treatment other than by moderate screening which we understand is provided, will be unnecessary for satisfactory disinfection.

249. Total Suspended Matter.

FULLER, GEORGE W. Estimated Total Dry Sludge or Suspended Matter in Various Municipal Sewages. Sewage Disposal, New York, 1912. p. 22.

Place.	Parts per million.	Grams per capita daily.	Tons per million gallons, U. S.	Tons per 1,000 population per annum.
Plainfield, N. J.	173	60	0.72	24
Framingham, Mass.	212	70	0.88	28
Boston, Mass.	135	168	0.56	67
Gardner, Mass.	154	50	0.64	20
Marlboro, Mass.	137	57	0.57	23
Brockton, Mass.	195	55	0.81	22
Worcester, Mass.	256	175	1.06	70
Providence, R. I.	397	149	1.65	60
Columbus, Ohio	215	98	0.90	39
Chicago, Ill.	141	155	0.59	62
Waterbury, Conn.	165	....	0.69	....
Gloversville, N. Y.	406	....	1.70	....
Philadelphia, Pa.	189	....	0.79	....
Lawrence, Mass.	149	....	0.62	....

250. The Operating Control of Sedimentation Plants.

IMHOFF, KARL. *Engineering Record*, Vol. 62, p. 270–271, 1911.

251. Sludge Disposal.

PEARSE, LANGDON. *Jour. of the Western Society of Engineers*, Vol. 16, p. 565–589, Chicago, 1911.

The present problem is more nearly solved by the use of the Emscher tank, by its depth of 30 to 40 feet, because it produces a very compact sludge which contains a number of gas bubbles under pressure, which will expand when the sludge is run out on a drying bed, allowing the sludge to drain more quickly. This statement, however, has not been verified by us at the experimental testing station of the Sanitary District. Our tank was built in June, 1910, and

as yet, we have not removed any sludge. We do, however, know from experiments in this country that the idea is correct and we have also the German experience to guide us.

Sludge has an average water content of from 80% to 95%. In planning for a city located like Chicago, the question of sludge disposal cannot be passed over casually. It is a real, live issue, since the sludge should not be put into the lake, and cannot be put into the canal. Some method of land disposal, therefore, must be figured on. If the sludge be dried on sand-beds, septic or sedimentation sludge requires about 30 days to be spadeable, whereas it is claimed for the Emscher tank sludge that from 3 to 7 days are sufficient. The resulting air-dried sludge can be used for filling or even burned, with the addition of a small amount of fuel.

252. The Emscher Sewage District and the Imhoff Tank.

Saville, Charles. *Jour. of the Association of Eng. Societies*, Vol. 47, p. 1–58, Boston, 1911.

Sludge, after remaining the necessary time in the decomposing chamber, has changed materially from its original condition. It is a black semi-liquid, uniform porous mass having a slight odor of tar or burnt rubber. It is oily in appearance like the soil sometimes found in low swampy land. About one third of the organic matter originally present in the sludge has been converted into gas, the remainder being non-putrescible. The sludge contains on an average only 75% of water and therefore occupies much less space than when first deposited (in its fresh condition) in the tank. As a result, however, of its gas content and the destruction by decomposition of the fibrous material, it flows easily in channels having a slope of 1:40. Its temperature varies between 55° and 63° F., and does not decrease noticeably in cold weather.

The sludge is dried on well underdrained open beds, containing 10 to 12 inches of graded slag. The necessary drying time is short, averaging six days in dry weather; it will be spadeable at the end of three days. The gas content of the sludge has much to do with the rapidity of drying. When in the tank under 25 to 30 feet of water pressure the small gas bubbles held fast in the sludge become compressed. But as soon as the sludge is drawn out on to the drying beds this pressure is removed. The gases expand, making the sludge porous and light enough to float on the water. The volume of the sludge is reduced about 40% during drying. The dried sludge is less than 10% of the volume of the fresh sludge as originally deposited in the tank, and in the Emscher district, amounts to about 0.8 cubic feet per year per person connected with the tanks. One square foot of area is ordinarily provided for every three persons.

At most of the plants operated by the Emschergenossenschaft, the sludge is used for filling in low areas, being shoveled from the drying beds into small cars on rails and pushed by hand to the dump. The dried sludge is firm, porous and free from disagreeable odor. It looks much like garden loam.

253. Suspended Matter at Chicago.

WISNER, GEORGE M. From report to the Sanitary District of Chicago, October, 1911. p. 19.

It is estimated that at present there is being discharged into the river and main channel from human sources alone in a year over 137,000 tons of dry material in suspension. Of this possibly 40% may settle. Roughly, this represents about 640,000 cubic yards of liquid sludge per year. The disposal of sludge need not be so appalling as regards quantity. In 1909 the City of Chicago disposed of 93,268 tons of garbage at a cost of $4.42 per ton; 1,234,192 cubic yards of ashes at approximately 57 cents per cubic yard.

254.

Ibid., p. 44.

From a study of the plans of various types of settling basins, I find that an allowance should be made 0.5 to 1.1 square feet per capita with the flows to be expected in Chicago. For the Emscher tank of the design in mind 0.63 square feet per capita is a reasonable net area, and an allowance of 1 square foot per capita is a reasonable gross area to cover the tanks and appurtenances, but not the sludge drying or sludge disposal.

255.

Ibid., p. 44.

From a study of the designs abroad, the Atlanta design, and our experience at Thirty-ninth Street testing station, I am satisfied that an allowance of 0.3 square feet per capita net area is reasonable for the sludge drying bed. For the gross area to include tracks, dikes, distribution, etc., about 0.5 square feet per capita is required. The cost may be taken in round figures at 15 cents per capita including appurtenances.

256. Sewage Sludge Treatment and Utilization of Sludge.

ELSNER, A. The Drying of Sludge.

SPILLNER, F. (trans. by K. and R. S. Allen). Operation of Mechanical Sewage Plants.

SPILLNER, F. and BLUNK (trans. by E. Kuichling). Sludge Treatment in the United States.

257. Emscher Tanks for Erie.

Emscher Tanks for Erie, for the Clarification of Sewage to be discharged into Lake Erie; Detail Plans for 115 Million gallon Plant. *Municipal Jour.*, Vol. 30, p. 228–231, 1911.

ADOPTION, ACTUAL AND PROSPECTIVE OF SEWAGE STERILIZATION BY CHLORIDE OF LIME IN AMERICAN CITIES.

A number of sterilization plants in seaboard cities of New Jersey, have been described in the Reports of the New Jersey State Board of Health. From the report of 1911, we mention:

258. Atlantic City.

The hypochlorite plant for the treatment of the sewage of Chelsea district of Atlantic City, is situtated at the end of Raleigh Avenue near the Thoroughfare and was put in operation about August 10, 1911.

259. Bridgeton.

The Bridgeton sewage disposal plant consists of two hypochlorite disinfection plants, one on each side of the Cohansey Creek.

260. Keyport.

A plant for the disinfection of the sewage of Keyport with hypochlorite of lime is under construction and may be completed during December, 1911.

261. Margate City.

At Margate City, two hypochlorite disinfecting plants have been built, situated at the ends of Adams and Nassau avenues.

263. Ocean City.

A hypochlorite plant for disinfecting the sewage of Ocean City has just been installed.

264. Stone Harbor.

The hypochlorite disinfection plant at Stone Harbor has been described in the State Board of Health Report for 1909, p. 247.

265. Plans for Purification Works.

Proposed Joint Sewage Purification Works for Orange, Montclair and East Orange, N. J. Calculated for 17,000,000 gallons per day. *Engineering News*, Vol. 67, p. 898–899, 1912.

The plans include a course screen, grit chambers, Imhoff settling tanks, sludge-drying beds, dosing tanks, sprinkling or percolating filters, a chemical house for preparing and applying hypochlorite of lime for disinfection, final settling tanks and laboratory.

On the way to the final settling tanks the filter effluent will pass through a chemical house and receive hypochlorite of lime for disinfection. There will be two dissolving tanks, six solution tanks, and two feed regulators for pre-

paring, standardizing and applying the hypochlorite. To apportion the volume of disinfectant to the volume of flow a 48-inch Venturi meter will be set in the sprinkling filter effluent pipe and properly connected with the feed regulators. The latter will be set to give the proper rate of dosing for a given flow through the meter, and as this flow increases or decreases the difference in pressure in the two pressure chambers of the meter will change the differences in volume of the applied hypochlorite accordingly.

266. Pennypack Creek Works.

THE Pennypack Creek Sewage Disposal Works, Philadelphia. *Engineering Record*, Vol. 63, p. 48–50, 1911.

By the Pennsylvania State Law 1905, the discharge of sewage and garbage into the waters of the state is to be prohibited, and all cities and towns tributary to the rivers are compelled by 1912 to have complete sets of plans ready and accepted by the State Board of Health for sewage and garbage disposal other than by dumping into creeks.

The Philadelphia City Council then directed the Department of Public Works to establish an experimental station to study matters of sewage disposal for the city. In 1908 there was organized a division of the Bureau of Surveys and placed under direction of Principal Assistant Engineer, George E. Datesman. The operative force began work March 23, 1909, and conducted the same until May 15, 1910. A new plant is being built to operate 2,000,000 gallons of sewage per day, based on the result of this experimental plant and pending treatment of the whole city sewage in the same manner.

The sedimentation tanks, Emscher type, will be of reinforced concrete; the biological percolating filters will be about one acre in extent and the effluent will enter a final sedimentation basin, a portion of which will be given over to sterilizing with hypochlorite of lime. The final effluent will run into Pennypack Creek.

267. The Sewage Disposal Works of Baltimore.

Engineering Record, Vol. 59, p. 237–238, 1909.

268. The Sewage Disposal Works at Baltimore.

Engineering Record, Vol. 65, p. 200–202, 1912.

An act passed by the legislature in 1905, created the present Sewage Commission of Baltimore, and made it mandatory that the sewage be purified.

The act gave no authority for the construction of a system involving the discharge of raw sewage as distinguished from storm water or ground drainage into the Chesapeake Bay or any of its tributaries.

The first installation of purification works, under the direction of Mr. Calvin W. Hendrick, chief engineer, is now practically completed and ready for service. They consist of sedimentation tanks, rotary screens of fine mesh, sprinkling filters, and final settling tanks.

The hypochlorite treatment had not passed beyond the experimental stage in 1906, and final sand filtration was considered by the Board of Advisory Engineers. Later it was decided to omit the sand filters, and to adopt the hypochlorite treatment if need be.

269. Disinfection at Baltimore and Providence.

PHELPS, E. B. *American Jour. of Public Health,* Vol. 2, p. 71–86, New York, 1912.

At Baltimore, disinfection was substituted for the sand filters, saving in initial cost about a million dollars, and in annual operation over twenty-five thousand dollars.

In Providence, R. I., 20,000,000 gallons sewage are disinfected daily.

Examinations of the oyster-beds this fall, previous to certification by the State Commission of Shell-Fisheries, showed that many acres of beds that were condemned a year ago can now be certified under the rigid standards of that commission and that the dead line for oysters has moved a long way up the Narragansett Bay, a result due without doubt to the disinfection treatment.

270. The Rocky Mount Sewage Sterilization Plant.

PHELPS, E. B. *Municipal Journal,* Vol. 32, p. 665–668, 1912.

The Rocky Mount plant was designed for a population of about four or five thousand people and cost in the neighborhood of $6,000 complete. It comprises a screen, a detritus tank, two preliminary tanks, and the disinfecting chamber proper, together with suitable apparatus for the preparation and proper admixture of the disinfectant. Hypochlorite is being added at the rate of 25 lbs. per day, or approximately 90 lbs per million gallons.

The actual labor involved in the operation of this plant requires less than two hours per day of the attention of an unskilled laborer, and the somewhat careful supervision of this man's work by the superintendent in charge. The average results were as follows:

Bacteria growing at body temperature................	99.7% removal
Bacteria growing at room temperature.................	96.9% "
B. coli..	96.1% "

271. Disinfection at Ligonier, Pa.

Engineering Record, Vol. 65, p. 434–435, 1912.

This community of 2,000 population is required by the State Board of Health to disinfect effluent from the sewage purification plant, now (1912) under construction. The bleach solution will be applied between the sprinkling filters and the secondary sedimentation tank.

HISTORICAL.

272. Former Views.

PHELPS, E. B. Former Views on Germicidal Merits of Chloride of Lime in Sewage Disinfection. *Water Supply Paper*, No. 229, U. S. Geological Survey, Washington, 1909.

The Board of Advisory Engineers at Baltimore stated in regard to disinfection by chemical means "To remove all bacteria remaining in the settled effluent from the sprinkling filters by disinfectants, such as hypochlorite of lime or of sodium, or sulphate of copper, prohibitively expensive," an authoritative opinion based on the best evidence then to be had. Almost no American data on chemical disinfection were available, and the result of experiments in Germany indicated that such disinfection could be accomplished only at high cost.

At the Royal Testing Station in Berlin, the subject of Sewage Disinfection has been studied by Kranepuhl and by Kurpjuweit. Kranepuhl undertook to determine the concentration of chloride of lime and the time of contact necessary to destroy the colon bacilli in crude Berlin sewage.

Kranepuhl's results are summarized in the following table in which positive tests mean that B. coli was found in one liter.

Available chlorine (in parts per million).	Time of Exposure. Hours.	B. coli in liter samples.		
		Number of Samples tested.	Number of positive tests.	Per cent positive tests.
50	2	20	11	55
50	4	9	2	22
60	2	17	6	35
60	4	6	3	50
150	2	19	4	21
150	4	10	1	10
300	2	16	1	6
300	4	7	0	0

A review of the available data and short experimental investigation made in 1906 at Boston led Phelps to believe that there is much value in the process and that it might afford the best possible solution of the whole problem under certain conditions common in this country, particularly in localities where the shellfish question is involved.

Professor Phelps, describing in such modest terms the birth of his epoch-making process or Sewage Disinfection must naturally have been mindful of

the work done by others before him. (Rideal, S., On the sterilization of effluents: *Jour. Royal Sanitary Institute,* Vol. 26, p. 378.) But the great merits of Phelps lie in his sound judgment, which made him to relinquish the extreme standards of bacterial purity aimed at by former investigators.

Dr. Dupré sterilized sewage, and kept it for weeks without the slightest change. By adding a little non-sterilized sewage, decomposition at once began. Mr. Warrington has found similar evidence. Dr. Emmich has shown that sterilized sewage continuously aërated by sterilized air, did not oxidize perceptibly, nor purify itself at all.

273. Early Experiments in Disinfection.

In the First Experiments on Sewage Disinfection by Hypochlorites, at Brest and Nice, France, and Worthing, Eng., in 1894, the agent was applied not to the raw liquid, but as a finisher to a sewage already partly purified.

Rideal (1898) found that in a purified effluent at Maidenhead, 17 parts available chlorine per million, killed all organisms in 15 minutes.

In his trials at Guildford, extending over several years, Rideal disinfected raw sewage and septic sewage with 30 to 70 parts of available chlorine per million (from 700 lbs. to 1,600 lbs. chloride of lime per 1,000,000 U. S. gallons).

We at this day, being in practical touch with the blessings of sewage disinfection and water sterilization, read with wonderment the theoretical objection to either in the European scientific press. Today, sewage is being sterilized with 5 to 10 parts available chlorine per million in a number of American cities. That quantities many times larger are stated to be inefficient in the data above quoted, had principally been caused by the insistence on enrichment methods of bacteriological testing.

If, as has been proven, more than 99% of sewage or water bacteria can be destroyed by very moderate quantities of chloride of lime, while the remnant which is made to multiply and come into evidence by enrichment methods would require very large doses; then, let it be determined at the outset what merits there are in a 99% disinfection.

This is what Phelps has done. He investigated the relations between a 98 or 99% disinfected sewage and all the other factors, viz., the factors that could bring about this result, as concentration of disinfectant, time of contact, cost, efficiency, and particularly factors beyond—such as self-purification of rivers, and for the first time in the history of the subject, the disinfection of sewage was shown to be practical and feasible.

FURTHER BIBLIOGRAPHICAL REFERENCES ON STERILIZATION OF SEWAGE.

274.

WINSLOW, C.-E. A. and BELCHER, D. M. Change of the Bacterial Flora in Sewage during Storage. *Jour. Inf. Diseases*, Vol. 1, p. 170–192, Chicago, 1904.

275.

The Sewage Testing Station for the City of Philadelphia. *Engineering Record*, Vol. 60, p. 71–73. New York, 1909.

276.

CLARK, H. W. and GAGE, STEPHEN DEM. A Review of Twenty-one years Experiments upon the Purification of Sewage at the Lawrence Experiment Station. In 40th *Ann. Rep.* Mass. State Board of Health, Boston, 1909.

277.

PHELPS, E. B. U. S. Geological Survey, Water Supply Paper 229. Washington, 1909.

278.

PHELPS, E. B. The Disinfection of Sewage and Sewage Filter Effluents. *Jour. Assn. of Engineering Societies*, Vol. 46, p. 12–45, Boston, 1911.

279.

PEARSE, LANGDON. The Sewage Testing Station of the Sanitary District of Chicago. *Engineering News*, Vol. 63, p. 367–372, New York, 1910.

280.

PHELPS, E. B. The Disinfection of Water and Sewage (with Discussion). *Proc. Eng. Club of Phila.*, Vol. 27, p. 135–151, Philadelphia, 1910.

281.

HERING, R. Sewage Disposal in Europe. *Engineering Record*, Vol. 62, p. 707–708, 1910.

282.

KINNICUTT, L. P., WINSLOW, C.-E. A., and PRATT, R. W. Sewage Disposal (with good bibliography). New York, 1910, 436 p.

283.

HOLMES, W. C. Bibliographical Reference List. *Carnegie Library of Pittsburgh Monthly Bull.* Vol. 15, p. 488–578, Pittsburgh, 1910.

284.

PHELPS, E. B. Sewage Purification; Its Theory and Present Day Practice. *Jour. of the Engineers' Society of Pennsylvania*, Vol. 2, No. 11, 1910.

285.

SCHMIDTMANN, H., THUM, K. and REICHLE, C. Beseitigung der Abwässer und ihres Schlammes. (Sewage and Sewage Sludge.) In *Handb. d. Hygiene* (by M. Rubner, M. v. Gruber and M. Ficker), Vol. 2, Sec. 2, p. 151–334, Leipzig, 1911.

286. Sterilization of Water and Disinfection of Sewage.

JOHNSON, GEORGE A. Sterilization of Public Water Supplies.

PHELPS, E. B. Disinfection of Sewage and Sewage Filter Effluents.

Discussion by:

PRATT, G. H., WESTON, R. S., CLARK, H. W., WINSLOW, C.-E. A., GAGE, S. DEM., KINNICUTT, L. P., JOHNSON, G. A. and PHELPS, E. B. *Jour. of the Association of Engineering Societies*, Vol. 46, p. 12–45, Boston. 1911.

287.

PEARSE, LANGDON. Sewage Disposal in the United States and Abroad. *Jour. of the Western Society of Engineers*, Vol. 16, p. 565–591, 1911.

288.

Partial Report upon the Comprehensive Plan for the Collection, Purification and Disposal of the Sewage for the Entire City. Report of the Bureau of Surveys, comprising the work at the Sewage Experiment Station at Spring Garden, Philadelphia, 1910. 204 p., 43 diagr., 24 pl., 18 tables. Philadelphia, 1911.

289.

PHELPS, E. B. The Chemical Disinfection of Sewage. *American Journal of Public Health.* Vol. 2, p. 72–76, New York, 1912,

290.

FULLER, G. W. Sewage Disposal. New York, 1912. 767 p.

LIFE HABITS OF THE HOUSE FLY.

291. Control of Flies and other Household Insects.

FELT, E. P. *N. Y. State Museum Bulletin*, No. 136, Albany, 1910.

Habits. The house fly breeds by preference in horse manure, though it lives to a limited extent in cow manure and miscellaneous collection of filth, especially decaying vegetable matter. The flies deposit their eggs upon manure and similar material, the maggots hatch in less than 24 hours, and, under favorable conditions, complete their growth in 5 to 7 days. The white conical maggots some half an inch long then transform to an oval brown, resting or pupal stage, remaining in this condition from five to seven days. The life cycle is therefore completed in 10 to 14 days, the shorter period being true of

the warmer parts of the year, particularly in the vicinity of Washington, D. C. One fly may deposit 120 eggs, and there may be ten or twelve generations in a season; it is not surprising that this insect should become extremely abundant in midsummer. It has been estimated that 1200 house flies might be bred from a pound of manure, and at this rate a good load would produce two and a half millions. Fortunately, breeding is confined to the warmer months, only a few flies wintering in houses in a more or less dormant condition.

292. Comparative Fecundity in Relation to Media.

The following important results from investigations made by Professor Forbes, State Entomologist for Illinois, in conjunction with Messrs. Girault and Davis on Comparative Fecundity of Flies in different Media are taken from Dr. Howard's book on the House Fly, p. 17:

Date.	Media.	Number house flies bred.
Sept. 1–3.	Rotten watermelon and muskmelon	14
Aug. 18. Sept. 8–11.	Rotten carrots and cucumbers	23
Sept. 7.	Rotten cabbage stump	1
Sept. 7.	Banana pealings	1
Aug. 30.	Rotten potato peelings	12
Sept. 25.	Cooked peas	1
Oct. 1.	Ashes mixed with vegetable wastes	1
Sept. 7–14.	Rotten bread or cake	8
Aug. 22.	Kitchen slops and offal	193
Sept. 10–26.	Mixed sawdust and rotting vegetables	41
Aug. 30. Sept. 4.	Old garbage, city dump	15
Aug. 14–18.	Rotten meat, slaughter houses	40
Aug. 30. Sept. 11.	Carrion in street	267
Sept. 7.	Seepage from garbage pipe	1
Aug. 17–20.	Hogs' hair, slaughter house waste	9
Aug. 23–28.	Sawdust sweepings, Stock Yards slaughter house	110
Aug. 23.	Sawdust sweepings, meat market	4
Aug. 16–28.	Animal refuse, Stock Yards	39
Aug. 14.	Contents of paunches of slaughtered cattle	168
Sept. 2–11.	Rotten chicken feathers	258
Aug. 16.	Chicken manure, stock-car dump	3
Aug. 31. Sept. 7.	Cow dung, stable manure, Urbana	997
Sept. 7–10.	Cow dung, outdoor yard	22
Sept. 6.	Cow dung, pasture	1
Aug. 24. Sept. 16.	Human excrement	196

293. Habits of the Common Fly.

Newstead, R. Habits, Life-Cycle and Breeding Places of the Common House Fly as observed in the City of Liverpool. Liverpool, 1907.

Flies breed in horse manure, a mixture of this with cow dung, fermenting hops, ash pits containing fermenting vegetable matter and all temporary collections of fermenting matter. They feed on most decaying vegetable matter, manure and particularly human, rotten flock beds, straw mattresses, old cotton garments and sacks, and waste paper, bread, fruits and vegetables and excreta of animals generally.

GENERAL STATEMENT ON INFECTION BY FLIES.

294. The Disease-Carrying House Fly.

Jackson, Daniel D., Bacteriologist for the Department of Water Supply, Gas, and Electricity of the City of New York. *American Review of Reviews*, Vol. 42, p. 44–48, New York, 1910.

Moses must have had some realization of the danger from flies, for he witnessed their dreadful ravages among the Egyptians at the time of the captivity of the Israelites. But probably even before, and certainly many times since, have thinking people suspected the malevolence of this plague. It was not until very recent years, however, that specific evidence has been gathered which has convicted the fly of guilt beyond a doubt, and only during his recent trial have the extent and enormity of his crimes been established.

The chief specialties of the fly are now known to be the transmission of intestinal diseases, typhoid fever, cholera, and diarrhœa. It has also been pointed out in recent studies by the Local Government Board of London that he may very possibly carry tuberculosis, anthrax, diphtheria, ophthalmia, smallpox, staphylococcus infection, swine fever, tropical sore, and the eggs of parasitic worms.

Hence the vigorous campaign now being carried on against the house fly by civic associations and health boards throughout the country. In many cities placards have been pasted warning the people in terse text and graphic pictures of the danger from flies, and giving rules for protection against them; lectures on the subject are also being widely given, and even that new popular fad, the moving picture show, had been brought into service to educate the public to the dangers of the *musca domestica*, as the house fly is scientifically termed, or, as Dr. L. O. Howard has aptly named it, the "typhoid fly." Over 98% of the flies that visit our homes and surroundings belong to this dangerous species.

This so-called harmless insect is one of the chief sources of infection, which in New York City causes annually about 650 deaths from typhoid fever and about 7,000 deaths yearly from other intestinal diseases. The statistics in practically all American cities—and in many foreign cities, too, for that

matter—show a marked rise in the number of deaths from typhoid fever and intestinal diseases during the fly season.

In cities where flies are the chief cause of intestinal epidemics, the other seasons of the year show comparative freedom from the diseases, while in cities where water and milk epidemics exist these epidemics may occur at any season of the year. The milk epidemic, however, often takes place during fly season because of the infection of milk by flies at the farm or in the local milk depots.

295. The Messengers of Death.

Williams, Dr. Henry Smith. *Cosmopolitan Magazine,* Vol. 53, p. 724–735. New York, 1912.

In this article the author describes in a masterly way, the subject of infection by the house fly and other insects; he discusses available means which are used now for combating this scourge.

296. The Carriage of Infection by Flies.

Buchanan, R. M. *Lancet,* 1907, II, p. 216–218, London.

Experiments conclusively show that flies alighting on any substances containing pathogenic organisms are capable of carrying away these organisms in large numbers on their feet and of depositing them in a gradually diminishing number on surface after surface with which they come in contact.

297. Conveyance of Disease by Flies.

Jackson, D. D. Reviewed in editorial in *Boston Medical and Surgical Journal,* Vol. 159, p. 45, 1908.

Summary states that the relation between the number of flies captured and the number of deaths reported are substantially the same as in 1907. A notable decrease in mortality this summer corresponded with catching a much smaller number of flies.

Jackson finds on 18 swill-barrel flies 118,800,000 bacteria or over 6,600,000 to each fly.

298. Intestinal Diseases and the Fly.

Jackson, Daniel D. Pollution of New York Harbor as a Menace to Health by the Dissemination of Intestinal Diseases through the Agency of the Common House Fly. Published by the Merchants' Association of the City of New York, 1908.

A detailed examination of local conditions showing that by far the greater number of cases of typhoid fever in 1907 occurred within a few blocks of the water front, the outbreak being most severe in the immediate vicinity of sewer outlets. The same was also found true of deaths resulting from intestinal diseases. Charts are given showing an almost exact coincidence between deaths from the latter and the prevalence of the house fly. The same is shown to be true of typhoid fever when the dates are set back two months to correspond to the time at which the disease was contracted. Several epidemics of

dysentery of a malignant type have been known to radiate from a single point and to entirely disappear when proper disinfection of closets was enforced. On several occasions local epidemics of typhoid fever was traced to transmission by flies.

299. Hardihood of B. Typhosus.

FAICHNIE, N. *Jour. Royal Army Medical Corps*, Vol. 13, p. 672–675, London, 1909.

Flies from the artillery lines were mashed up in sterile salt solution, and B. typhosus was separated. Each was transfixed with a sterile needle, passed two or three times through a flame until the legs and wings were scorched, and was then put in a normal salt solution and stirred. After this they were mashed up and B. typhosus was found.

300.

BRITTON, W. E. The Rôle of the House Fly and Certain Other Insects in the Spread of Human Disease. *Pop. Science Monthly*, Vol. 81, p. 36–49. Lancaster, 1912.

301. House Flies as Carriers of Disease.

NASH, J. T. C. *Jour. of Hygiene*, Vol. 9, p. 141–169. Cambridge, Eng., 1909.

Dr. Nash is a recognised authority on Infant Mortality.

302.

PALMER, DR. J. W., Ailey, Ga. *Jour. Record of Medicine*, Vol. 12, p. 77–87, Atlanta, 1909.

Estimates that 95% of the typhoid fever in rural districts may be laid to the typhoid fly. He states that during the past typhoid season he treated fever in several families, and especially noticed that in the families which controlled the flies as directed by him no new cases developed, while families which did not control the flies had anywhere from one to four cases in each family. He points out that in one year typhoid causes more deaths than yellow fever in fifty years and quotes Dr. L. O. Howard: "It is the duty of every individual to guard so far as possible against the occurrence of flies upon his premises. It is the duty of every community through its Board of Health to spend money in the welfare against this enemy of mankind."

303. Number of Bacteria Found on Flies.

ESTEN, W. N. and MASON, C. J. *Bulletin of the Agricultural Experiment Station*, No. 57, Storrs, Conn. 1908.

The method of the experiment was to catch the flies from the several sources by means of a sterile fly net, introduce them into a sterile bottle and pour into the bottle a known quantity of sterilized water, then shake the bottle to wash the bacteria from their bodies, to stimulate the number of organisms that would come from a fly falling into a lot of milk.

The average was 1,222,570 bacteria per fly on 414 flies investigated.

INFECTION OF MATERIALS ON WHICH FLIES FEED.

Sources of Bacteria from Flies.

1907.	Source.	Total number.	Total acid bacteria.	Rapid liquefying bacteria.	Slow liquefying bacteria.	Bacterium lactis acidi Group A, Class 1.	Coli-aërogenes Group A, Class 2.
July 27	(a) 1 fly. Bacteriological laboratory.........	3,150	250	600	100	....	....
July 27	(b) 1 fly. Bacteriological laboratory.........	550	100	....	....	....	....
Aug. 6	(c) 19 cow stable flies..........	7,980,000	200,000	....	20,000	....	....
	Average per fly	420,000	11,600	....	1,000	....	....
Aug. 14	(d) 94 swill-barrel flies..........	155,000,000	8,950,000	....	....	4,320,000	4,630,000
	Average per fly	1,660,000	95,300	....	....	46,000	49,300
Aug. 14	(e) 144 pig-pen flies	133,000,000	2,110,000	100,000	266,000	933,000	1,176,000
	Average per fly	923,000	13,700	700	1,150	6,500	12,200
Sept. 4	(f) 18 swill-barrel flies..........	118,800,000	40,480,000	....	14,500,000	10,480,000	30,000,000
	Average per fly	6,600,000	2,182,000	....	804,000	582,000	11,600,000
Sept. 21	(g) 30 dwelling house flies..........	1,425,000	125,000	....	12,500	....	....
	Average per fly	47,580	4,167	....	417	....	....
Sept. 21	(h) 26 dwelling house flies..........	22,880,000	22,596,000	120,000	34,000	....	....
	Average per fly	880,000	869,000	4,600	1,300	....	....
Sept. 27	(i) 110 dwelling house flies....	35,500,000	13,670,000	8,840,000	125,000	....	....
	Average per fly	322,700	124,200	80,300	1,000	....	....
Aug. 20	(j) 1 large blue bottle blow fly...	308,700	(*a*)	....	....	....	....
	Total average of 414 flies........	1,222,570	367,300	7,880	73,500	....	....
	Average per cent 414 flies........	....	30%	6%	6%	....	....
	Average per fly, 256 flies; experiments (d), (e), (f)	3,061,000	765,000	230	268,700	211,500	553,800
	Average per fly, 256 flies, experiments (d), (e), and (f) .	....	25%	....	8%	7%	18%

(*a*), 2,200 mold spores.

304.

FIRTH, R. H. and HORROCKS, W. H. An Inquiry into the Influence of Soil, Fabrics, and Flies on the Dissemination of Enteric Fever. *British Medical Journal*, 1902, II, p. 936–943, London.

M. domestica were kept in box measuring four by three feet, with one side made of glass. They were fed on material contaminated with cultures of B. typhosus. Agar plates, litmus, glucose broth, and a sheet of clean paper were at the same time exposed in the box. The authors conclude that M. domestica can convey B. typhosus from infected sources to objects upon which they walk, rest, or feed, and that bacilli adhere to the external parts of flies.

305.

GRAHAM-SMITH, G. S. Further Observations on the Ways in Which Artificially Infected Flies Carry and Distribute Pathogenic and Other Bacteria. Reports to the Local Government Board of England and Wales on Public Health and Medical Subjects. (New series No. 53.) London, 1911. p. 34.

Three sets of flies were carefully infected by feeding on syrup containing the suspension (1) B. prodigiosus (2) B. pyocyaneus, and (3) a spore-bearing culture of B. anthracis, respectively. The flies were then transferred to clean cages. Two and a half hours after feeding, a watch glass containing sterile milk was placed in each cage and removed after the flies had fed on it. Cultures were then made from the specimens of milk. The flies were fed daily in this way for several days, and after each feeding removed to clean cages.

Table showing results of cultures from samples of milk on which flies, infected with B. prodigiosus, B. pyocyaneus and B. anthracis, had been allowed to feed:

Time after flies were infected.	B. prodigiosus.	B. pyocyaneus.	B. anthracis.
2½ hours	+++	+++	+++
1 day	+++	+++	+++
2 days { dry milk	+++	+++	+++
2 days { fluid	+++	+++	+++
3 days { dry milk	+++	+(3 colonies)	+++
3 days { fluid milk	+++	+(3 colonies)	+++
4 days	++	0	+++
5 days	–	+(1 colony)	++
6 days	+	0	+(1 colony)
7 days	+	0	+(3 colonies)
8 days	+	0	+
9 days	+	0	0
10 days	+	0	0
11 days	+(3 colonies)	0	+(1 colony)

All these experiments show that artificially infected flies, kept in captivity, may contaminate milk on which they feed for several days.

"The experiments and observations quoted in this paper show definitely that artifically infected flies, both house flies (M. domestica) and blow flies (C. erythrocephala) are capable of infecting fluids, such as milk and syrup, on which they feed and into which they fall. In the case of the house fly, infected with certain microörganisms (B. prodigiosus and B. anthracis) gross infection may be produced in milk for at least three days, and a smaller degree of infection for ten days, or even longer. Blow flies produce gross infection for six to nine days with non-spore-bearing microörganisms (B. prodigiosus and B. pyocyaneus) and some degree of infection for three or four weeks. It is probable, at any rate, in the later stages, that infection is mainly due either to direct infection with the crop contents vomited through the proboscis, or to indirect infection by means of the limbs which have been reinfected with vomited material during the process of cleaning them."

RANGE OF FLIGHT OF FLIES.

306.

Copeman, S. M., Howlett, F. M. and Merriman, G. An Experimental Investigation on the Range of Flight of Flies. Reports to the Local Government Board, etc. New Series, No. 53, London, 1911. p. 10.

As the outcome of these experiments not only has evidence been obtained not previously available, as to the range and rapidity of the flight of flies between their breeding place and human dwellings at a distance, but, in the particular case under consideration, proof has been afforded that flies, captured in the village of Postwick, have made their way thither from the refuse deposit on the Whitlingham Marshes, notwithstanding the fact that the river Yare and, at Postwick Grove, a hill of moderate elevation, intervene.

Table giving details of Three Experiments on Range of Flight of Flies, at Postwick.

Date.	Weather.	Time of liberation.	Date of recovery of flies.	Distance traveled in yards.
Aug. 20	Dull	12 to 2 p. m.	Aug. 21	400
		3 to 4 p. m.	21	1,085
21	Bright	4 p. m.	22	850
			23	1,408
22	Bright	3 p. m.	22	300–700
			22	800
			23	850
			23	1,050
			23	1,027
			23	1,173
			24	997
			24	1,027
			24	850
			24	980
			25	1,408
			25–26	850

307. Notes on the Distances Flies Can Travel.

COBB, N. A. *National Geographic Magazine,* Vol. 21, p. 280-283, Washington, D. C., 1910.

308. Observations on the Range of Flight of Flies.

HEWITT, C. GORDON. Reports to the Local Government Board of England and Wales on Public Health and Medical Subjects. (New Series No. 66.) London, 1912.

FLIES FEEDING ON EXCREMENTS.

309.

NUTTALL and JEPSON. Reports to the Local Government Board of England and Wales on Public Health and Medical Subjects. (New Series No. 16.) London, 1909.

Smith (1904), writing of South Africa, states that a neglected trench "becomes an open privy with an infected surface around it; the flies browse in it in the daytime and occupy the men's tents at night."

310.

Ibid. Austen (1904), recalls "a latrine in a certain standing camp in South Africa during the late war, in which the conditions as regards flies were precisely as described by Major Smith. On visiting the latrine, a buzzing swarm of flies would suddenly arise from it. The tents at meal times, men's mess tins, etc., were always invaded by flies."

311.

Ibid. F. Smith (1903), refers to his experience in the South African War in seeing flies go from bed pans to milk, etc., and discusses in detail methods of sewage disposal in warm countries.

312.

L. O. HOWARD. "The House Fly."

The typhoid fly is attracted to human excreta, not only for food, but lays its eggs upon it and lives during its larval life within it. It will not only do this in the latrines of army camps, in the open box privies of rural districts and small villages, but also upon chance droppings in the field or in the back alleyways of cities, as has been repeatedly shown experimentally in Washington.

313.

Stiles has found that in cotton mill towns, for example, the privies may be a much more important breeding place of flies than the manure piles, not only more important since flies breeding in this substance are more likely to carry disease germs, but also numerically more important, for you may have 250 uncared-for privies and perhaps only one or even no manure pile.

For suggestiveness and availability the name "filth fly" is proposed by Dr. C. W. Stiles of the U. S. Public Health and Marine-Hospital Service.

314.

Washington Academy of Science Proceedings, Vol. 2, p. 541–600.

A detailed study of the insects breeding in human excrement, with special reference to the house fly and its part in disseminating typhoid fever, is published. Unquestioned evidence is submitted to show that this insect may breed in human excrement.

315.

Surgeon-Major R. Macrae at the time of an outbreak of cholera in the jail at Gaja, writes, "The practical lesson upon the experiments teach us that flies should be looked upon in the light of posionous agencies of the worst kind during cholera epidemics, as it is clear that if they find access to poison they will carry and distribute it."

316.

Dr. C. W. Stiles told Dr. Howard that the causative organism of amœbic dystenery sporulates more readily as the feces dry. Therefore under a dry privy system this disease is the more likely to be carried by flies.

317.

Rideal, Dr. S. In "Disinfection," p. 350, says:

"One of the great dangers of leaving fecal matter exposed is the visits of flies. The bacteria of tubercle, splenic fever, typhoid and European cholera pass through the digestive organs of flies and reappear in their excrement with unabated virulence. . . . A covering of chloride of lime . . . has the merits of keeping them away."

318.

Stiles, Charles Wardwell. The Sanitary Privy: Its Purpose and Construction. *Public Health Bull.* No. 37, Washington, 1910, 24 p.

319.

Lumsden, L. L. Preliminary Note on a Simple and Inexpensive Apparatus for use in Safe Disposal of Night Soil.

Roberts, Norman, and Stiles, C. W. Repr. *Pub. Health, Rep.*, No. 54, Washington, 1910, p. 7.

320.

Stiles, Charles Wardwell and Lumsden, L. L. The Sanitary Privy. *Farmers' Bulletin*, No. 463, Washington, 1911, 32 p.

BACTERIAL DYSENTERY—INFANT MORTALITY.

321.

MARTIN, A. W. Flies in Relation to Typhoid Fever and Summer Diarrhœa. *Public Health,* Vol. 15, p. 652–653, 1903.

Each succeeding year confirms my observation in 1898 that the annual epidemic of diarrhœa and of typhoid is connected with the appearance of the common house fly. The annual epidemic of these two diseases begins and ends with the appearance and disappearance of the domestic fly.

322.

NUTTALL and JEPSON, *loc. cit.*

Newsholme (1903), has expressed the opinion that food in the houses of the poor can scarcely escape fæcal infection. "The sugar used in sweetening milk is often black with flies, which may have come from a neighboring dust-bin or manure heap, or from the liquid stools of a diarrhœa patient in a neighboring house. Flies have to be picked out of a half empty can of condensed milk before its remaining contents can be used for the next meal." Newsholme considers the greater prevalence of diarrhœa among infants fed on Nestle's milk as due to the fact that flies are more attracted to it than to ordinary cow's milk because of its sweetness.

323. The Etiology of Summer Diarrhœa.

NASH, J. T. C. *Lancet,* 1903, I, p. 330, London.

Twenty-three cases of the disease in Southend-on-Sea in 1901, whilst there were none in the summer of 1902. M. domestica absent in the hot summer of 1902, but appeared in September of the same year; coincident therewith there occurred 13 cases of infantile diarrhœa.

324.

SANDILANDS, J. E. Epidemic Diarrhœa and the Bacterial Content of Food. *Jour. of Hygiene,* Vol. 6, p. 77–92, Cambridge, Eng., 1906.

Conclusions. Great majority of cases are due to the consumption of food which has been infected.

Infected matter conveyed to food is generally the excrement of some person suffering from diarrhœa.

The life history of house flies and the facility with which they can convey the fecal excrement of infected infants to the food of the healthy, suggests that the seasonal incidence of diarrhœa coincides with, and results from, the seasonal prevalence of flies.

325. Infantile Diarrhœa and Flies.

AINSWORTH, R. B. *Journal of the Royal Medical Corps,* Vol. 12, p. 485–498, London, 1909.

Ainsworth studied the relation of infantile diarrhœa to flies in Poona and

Kirkee, India, and illustrates the relation by means of a yearly curve which is very striking as affording evidence that flies stand in causal relationship to diarrhœa.

326.

SNELL (1906), Medical Officer of Health, Coventry, is stated by Ainsworth to have shown that 70% of the "cases of infantile diarrhœa occurred in the northeast of his district, close to a large collection of refuse where flies swarmed."

327. House Flies as Carriers of Diseases.

NASH, J. T. C. *Journal of Hygiene*, Vol. 9, p. 141, Cambridge, Eng., 1910.

A thorough discussion, with special reference to infant mortality. Flies travel rapidly through liquid food (milk) and quickly contaminate a whole jug full.

Milk will become seriously contaminated if only one fly falls in. One fly falling into milk will, in mischief, equal a score or more flies on solid food.

All statistics, published in any country, point to one conclusion, that infantile diarrhœa among wholly breast-fed children is a negligible quantity as compared with the frightful mortality among the artificially-fed infants during the months when flies are excessive in prevalence.

It is to the infant that the fly-borne disease is especially harmful.

328. Experiments on Transmission of Bacteria by Flies.

ORTON, SAMUEL T. and DODD, W. L. Bacillary Dysentery at the Worcester State Hospital. *Boston Medical and Surgical Journal*, Vol. 163, p. 863–868, 1910.

An epidemic of 136 cases of bacillary dysentery occurred in the Worcester State Hospital. House flies, usually abundant, in spite of screening, were considered to be the carriers of the dysentery. It was finally discovered that the unusual number of the flies was due to piles of spent hops and barley malt which had been hauled in as fertilizer on the grounds. Conclusion as published is that flies were entirely responsible for the epidemic.

329.

DAVIES, W. H. Breast Feeding and Bottle Feeding in their Bearing on Infant Mortality. *American Journal of Public Health*, Vol. 2, p. 67–71, New York, 1912.

Recent investigations by the Boston Board of Health, show that of 621 deaths from diarrhœa and enteritis last year, between the ages of two weeks and one year, 87 were breast fed, and 534 bottle fed, *i. e.*, 86% were bottle-fed cases. If all the babies had been breast fed, the estimated number of these deaths would have been 493 less than actually occurred.

The reduction of infant mortality rate from 127 to 71 is entirely within the range of possibilities.

330. Special Report on Child Mortality.

Newsholme, A., Medical Officer to the Local Government Board for England and Wales. *Thirty-ninth Annual Report of the Local Government Board,* supplement containing report of the medical officer, London, 1910.

The defects of sanitation, which are specially associated with excessive infant mortality come under one of three heads; commonly all three occur in the same district.

1. Conservancy methods of disposal of excreta.
2. Inefficient scavenging of domestic refuse.
3. Unpaved or unmade-up roads and back streets and unpaved back yards of dwellings.

All these lead to dirtiness of the environment of the house, to treading of dirt, often of excremental origin, into the house.

The heaviest infant mortality from diarrhœa occurs in the districts in which the three forms of sanitary defects enumerated above are rife, and districts from which these defects are removed experience a lowering of infant mortality which is greater than that in which these evils continue.

As it is the excess of epidemic diarrhœa which largely determines excessive infant mortality, I may be permitted to give the main conclusions which I stated in 1899 as the result of epidemic diarrhœa in the 28 great towns in England.

1. Epidemic diarrhœa is chiefly a disease of urban life.
2. Epidemic diarrhœa as a fatal disease is a disease of the artisan and still more of the laboring classes to a preponderant extent.
3. Towns which have adopted the water carriage system of sewage, have as a rule much less diarrhœa, than those retaining other methods for removal of excrement.
4. Towns with the most perfect scavenging arrangements have the least epidemic diarrhœa.
5. Given two towns, equally placed so far as social and sanitary conditions are concerned, their relative diarrhœa mortality is proportionate to the height of the temperature and the deficiency of rainfall in each town, particularly the temperature and rainfall in the third quarter of the year.

331. Infant Mortality in the United States.

From *Mortality Statistics,* Bureau of the Census, 1910.

The total number of deaths of infants under one year of age in the registration area for the year 1910 was 154,373, or a little less than one fifth (19.2%) of all deaths that occurred. The number of deaths during the second year of life (33,080 or 4.1% of the total), though only about one fifth as great as the number during the first year, exceeded the number shown for any five-year period below the age of 35 years. Thus it is evident that the mortality of the first two years of life and especially that of the first year, is a very important factor in the general death-rate.

332.

Monthly Bulletin, October, p. 259–283, 1908. New York State Department of Health.

During 1907, there were in New York State, 37,370 deaths of infants under two years of age, 9,213 being due to diarrhœa and enteritis. Careful investigators have placed the proportion of deaths between bottle-fed and breast-fed babies as 25 to 1.

333. Infant Mortality in European and American Cities.

Population.		Death-rate. 1910	Population.		Death-rate. 1910
571,000	Amsterdam	78	237,194	Seattle, Wash	146
632,624	Sydney	82	207,214	Portland, Ore	155
240,000	Christiania	83	319,000	Los Angeles, Cal	164
341,000	Stockholm	92	416,912	San Francisco, Cal	167
588,971	Melbourne	92	301,408	Minneapolis, Minn	205
270,109	The Hague	93	213,381	Denver, Col	215
417,780	Rotterdam	94	181,511	Columbus, O	218
7,537,000	London	103	214,744	St. Paul, Minn	231
355,366	Edinburgh	111	168,497	Toledo, O	238
596,528	Milan	113	687,029	St. Louis, Mo	245
2,775,000	Paris	118	100,253	Albany, N. Y	248
455,000	Copenhagen	118	112,571	Grand Rapids, Mich	291
872,021	Glasgow	121	125,600	Paterson, N. J	300
546,882	Dresden	129	2,185,285	Chicago, Ill	311
402,928	Dublin	142	339,075	New Orleans, La	312
391,167	Belfast	143	331,069	Washington, D. C	321
834,000	Budapest	148	670,585	Boston, Mass	333
932,000	Hamburg	149	4,766,883	New York, N. Y	337
2,260,000	Berlin	157	1,549,008	Philadelphia, Pa	343
508,000	Prague	164	267,779	Jersey City, N. J	354
640,000	Rio de Janeiro	166	560,663	Cleveland, O	261
595,000	Munich	166	373,857	Milwaukee, Wis	364
2,130,000	Vienna	176	224,326	Providence, R. I	367
516,000	Breslau	188	588,485	Baltimore, Md	384
223,000	Trieste	190	129,867	Scranton, Pa	399
1,620,000	St. Petersburg	262	533,905	Pittsburgh, Pa	422
1,493,000	Moscow	297	363,591	Cincinnati, O	552
			119,295	Fall River, Mass	713

It should be observed here that in Europe, breast feeding is more general than in the United States, and that no amount of care in the selection of pure cow milk, or no efforts to cleanliness will compensate the fact that even the best cow's milk is liable to cause intestinal disorders.

334. Campaigning for Babies' Lives.

LEUPP, CONSTANCE D. *McClure's Magazine*, Vol. 39, p. 361, New York, 1912.

"Twice, and only twice in recent times, had the infant mortality rate shown a marked decrease.

"First, when the Civil War in this country caused a cotton famine in England, and the mills of Lancashire shut down, throwing thousands of operatives out of work, as the total death-rate among the shivering and starved population shot up, the baby death-rate dropped steadily to a figure unprecedentedly low even for prosperous times.

A few years later, when, during the Franco-Prussian War, the German army was bivouacked about Paris and privation and disease pushed up the death-rate of the French capital, the same strange phenomenon was observed; the babies throve on the hardships which killed off the adults, simultaneously, in those suburbs of the city from which in piping times of peace the rich little Parisians drafted their wet-nurses, the baby death-rate dropped from 35% to 17%, and remained at that figure during the time that communication with the City was cut off.

"The answer to the riddle in each case was the same: in prosperous times the young mothers went out to work; in hard times, when there was no work, they stayed home and nursed their babies.

"Thus the first commandment for the baby rescuers was established; better a thousand times the natural food and care of a mother, even an ill-nourished, poverty-stricken mother, than a plentiful supply of artificial food combined with neglect."

While ignorance and dirt prevailed the year round, it was in July and August that the results were actually registered, in mortality statistics. When the first dog-days struck the city, the babies went down before the heat. All the elements that make unendurable the living conditions of a great city's poor were registered in the sudden upward shoot of the curve of baby deaths. So perpendicularly does this "curve" run up with the first heat, so suddenly does it drop with the return of cool fall days, that it has earned for itself the classic name of the "Eiffel Tower."

INFANTILE PARALYSIS AND FLIES.

335.

RICHARDSON, DR. MARK W., Secretary State Board of Health of Massachusetts. Recent Contributions to Our Knowledge Concerning Infantile Paralysis. Paper read before the American Public Health Association, Havana, December, 1911.

Stress is laid upon the fact that an investigation by the Board in 1910 showed in every one of 88 cases the presence near the house, on the house, within the house and sometimes even in the sickroom itself of the ordinary biting stable fly, stomoxys calcitrans.

Without considering the theory of transmission by biting flies to be proven, the fact stands out, that in rural communities the disease is approximately ten times as frequent as in the larger cities.

336. The Control of Epidemic Poliomyelitis.

FLEXNER, S. *American Journal of Diseases of Children*, Vol. 2, p. 96–101, Chicago, 1911.

Insects that seek human habitations and routes of travel; that possess the power to migrate over a considerable territory; that affect all classes of society; that abound during the period of greatest prevalence of the disease, and that do not wholly disappear at any season, should be the first to come under suspicion. Many, if not all, of these conditions are fulfilled by the common house fly.

Laboratory-bred flies have been subjected to contamination experiments with the virus of poliomyelitis, from which it appears that they are capable of harboring the virus on their bodies in a living and infectious state for at least forty-eight hours. Moreover, it has developed that the virus also survives within the viscera of the insects for some time.

FLIES TRANSMIT INTESTINAL WORMS.

337.

NICOLL, DR. The Part Played by Flies in the Dispersal of the Eggs of Parasitic Worms. Reports to the Local Government Board for England and Wales, etc. (New Series No. 53.) London, 1911.

The foregoing observations serve to confirm the results of previous workers, in particular those of Grassi and Calandroccio.

The well-known habit of the house fly of feeding in turn upon excremental matter and human food stuffs, taken in conjunction with the fact that the spread of infection with parasitic worms depends in a large number of cases upon the dissemination of egg-laden excrement, constitutes a strong reason for suspecting the house fly of aiding in the spread of such infection. Flies feed readily upon infective material and even upon evacuated worms.

338. The Relations of Animals to Disease.

WARD, HENRY B. *Science*, Vol. 45, p. 194–195, Lancaster, 1905.

The spread of typhoid germs by flies is accepted and the reported conveyance by this insect, of cholera, anthrax, septicemia, pyemia, erysipelas, tuberculosis and bubonic plague is noted, some being regarded as well proved and others as open to question. Mention is made of Grassi's experiments in which the eggs of both tapeworms and round worms, tæniasolium oxyuria and trichuris were sucked up by flies and recovered unaltered from their dejecta.

FLIES AND TYPHOID FEVER.

339.

NUTTALL and JEPSON, *loc. cit.*

Hamilton (1903) in Chicago caught eighteen flies in and about houses and rooms occupied by typhoid cases, and states that she found B. typhosus in five of them.

340.

NUTTALL and JEPSON, *loc. cit.*

Tooth and Calverley (1901), writing of typhoid in camps during the South African War, state that "In a tent full of men, all apparently equally ill, one may almost pick out the enteric cases by the number of flies that they attract."

341.

NUTTALL and JEPSON, *loc. cit.*

"At Bloemfontein, the flies were a perfect pest. It is impossible not to regard them as important factors in the dissemination of enteric fever. The cold weather reduced the number of enteric cases by killing these pests."

Probably the first American to point out the probable transference of typhoid germs from box privies to food supplies by the agency of flies was Dr. George M. Kober of Washington, D. C. In 1895, Kober wrote:

"The agency of flies and other insects in carrying the germs from box privies and other receptacles for typhoid stools to the food supply cannot be ignored."

342.

HOWARD, L. O. From "The House Fly." p. 121.

A report by Maj. C. F. Wanhill on typhoid conditions in Bermuda shows that from 1893 to 1902 Bermuda had the highest enteric fever rate among the garrisons of any command occupied by British troops. Major Wanhill was placed in charge in 1904, and in two years almost wiped the disease out. He considered that carriage of the germs by flies was the most important mode of transfer.

343.

Dr. John R. Mohler, of the Bureau of Animal Industry of the United States Department of Agriculture, shows that typhoid bacilli will live in butter under common market conditions for 151 days. In milk under market conditions they retain active motility for twenty days, after which time there is a lessening in numbers until on the forty-third day of the test they disappear from view. Thus the eating of butter contaminated in this way may account for very many cases of typhoid fever the cause of which cannot otherwise be traced.

344.

LIEUT.-COL. F. W. JONES (1907) uses the following phraseology:

"Believing as we do that flies are the chief carriers of enteric fever in India, any plan which gets rid of them is worthy of consideration."

Colonel Jones writes: "I presume no one wishes to be a kakophagist, yet we are so in spite of ourselves, if flies bred in filth pits alight on our food just before we eat it." The high caste officers at first looked upon sanitary measures as being only meant to worry them, but Colonel Jones got several of them together and to the best of his ability explained that men who took no precautions in camps to prevent the breeding of flies must of necessity be kakophagists. He found that this appealed to them most strongly, and he had no further trouble.

345.

RILEY, C. V. Plymouth Typhoid, 1885. Cites an instance "in which the disease seems to have been transmitted through the air." The first case, that of a stranger, occurred in a hotel, the discharges being thrown without treatment into a water-closet which communicated with a room only three feet distant in which the landlord's daughter slept. The drinking water of the place was good and the three cases following the first were in all probability due to germs transmitted by flies.

During the Spanish-American War in 1898 the world got its first large-scale and convincing demonstration of the carriage of typhoid by flies, although the laboratory method was not used in this demonstration.

346. Typhoid During the Spanish War.

REED, WALTER, VAUGHAN, V. C., and SHAKESPEARE, E. O. Abstract of Report on the Origin and Spread of Typhoid Fever in the U. S. Military Camps during the Spanish War in 1898. Washington, 1900.

Flies undoubtedly served as carriers of the infection.

Reasons for believing that flies were active in the dissemination of typhoid fever may be stated as follows:

a. Flies swarmed over infected fecal matter in the pits and then visited and fed upon the food prepared for the soldiers at the mess tents. In some instances, where lime had recently been sprinkled over the contents of the pits, flies with their feet whitened with lime were seen walking over the food.

b. Officers whose mess tents were protected by means of screens suffered proportionately less from typhoid fever than did those whose tents were not so protected.

c. Typhoid fever gradually disappeared in the fall of 1898, with the approach of cold weather, and the consequent disabling of the fly.

It is possible for the fly to carry the typhoid bacillus in two ways. In the first place, fecal matter containing the typhoid germ may adhere to the fly and be mechanically transported. In the second place, it is possible that

the typhoid bacillus may be carried in the digestive organs of the fly and may be deposited with its excrement.

Infected water was not an important factor in the spread of typhoid in the national encampments of 1898.

347.

SEDGWICK, W. T. and WINSLOW, C.-E. A. Statistical Studies on the Seasonal Prevalence of Typhoid Fever in Various Countries and its Relation to Seasonal Temperature. *Memoirs American Academy of Science.* Vol. 12, p. 531–577, 1902.

Their investigation included an examination of the published data for all countries. They conclude that the increase of typhoid with a gradual rise in the mean air temperature is so widespread and significant as to indicate an undoubted relationship.

Of the three intermediaries of typhoid transmission, fingers, food and flies the last is even more significant than the others in relation to seasonal variation. There can be little doubt that many of the so-called "sporadic cases" of typhoid fever, which are so difficult for the sanitarian to explain, are conditioned by the passage of a fly from man-infected vault to an unprotected table or an open larder. The relation of this factor to the season is, of course, close and complete; and a certain amount of the autumnal excess of fever is undoubtedly traceable to the presence of large numbers of flies and to the opportunity for their pernicious activity.

The real explanation according to these authors, of the seasonal variations of typhoid fever is a direct effect of temperature upon the persistence in nature of germs which proceed from previous victims of disease. This, of course, means that there are more typhoid germs in late summer and autumn, and as there are at the same time more flies to carry them, the necessity of destroying flies, especially in the early summer, is emphasized by this conclusion.

348.

At the December, 1910, meeting of the American Association for Advancement of Science, at Minneapolis, Prof. F. L. Waeburn gave a lecture entitled "The Typhoid Fly on the Minnesota Iron Range," in which he gave results of a careful study of the conditions in certain mining towns in that state during the summer of 1910, in which the conditions were such as to make it perfectly plain that the main etiological factor in the typhoid epidemic then existing was Musca domestica.

349.

"Residuary" typhoid death-rates in American cities with improved water supply, representing cases caused by infected milk, flies, personal contact and such like avoidable occurrences which point to neglect or lack of intelligence in our populace are discussed in several bulletins by Dr. Allan J. McLaughlin of the U. S. Public Health and Marine-Hospital Service.

The *Engineering News*, Vol. 67, p. 746, 1912, comments: "It seems to us that 'poor control of milk or lack of control over patients and carriers' are usual rather than 'unusual' conditions in many cities with high typhoid rates and that these rates will not be reduced to 5 per 100,000 or for that matter to 10 or to 15, until *usual conditions* other than those of water supply are greatly improved."

350. Typhoid Death Rates in Some European and American Cities Before and After Introducing Pure Water Supplies.

Munich.

Typhoid death rate:

1856	1881–5	1886–90	1891–95	1907	1908	1909	1910
291	17	12	6	3	3	2	2

In the period 1856 to 1887 occurred a new water supply and sewering of the city.

Hamburg.

Typhoid death rate:

1880–92	1893	1894–98	1907	1908	1909	1910
39.7	18	7.2	3	4	3	5

Filtered water since May, 1893.

Philadelphia.

Typhoid death rate:

1903	1904	1905	1906	1907	1908	1909	1910
72.6	55	51.1	74.8	60.7	35.3	21.8	17.4

Part of water supply filtered since 1908.
Construction of whole filtering system completed in 1911.

Albany, N. Y.

Typhoid death rate:

1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900
66	116	56	59	57	169	102	88	100	87*	43

1901	1902	1903	1904	1905	1906	1907	1908	1909	1910
21	32	20	18	19	20	21	12	19	12

Lawrence, Mass.

Typhoid death rate:

1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900
135	120	108	80*	60	36	26	25	24	36	19

1901	1902	1903	1904	1905	1906	1907	1908	1909	1910
19	20	28	18	23	20	30	24	22	16

*Years of change from unfiltered to filtered water supply.

This comparison reveals in the American cities permanence of distressingly high "residuary typhoid rates" after the principal causation of typhoid, polluted water, had been removed.

FLIES AND CHOLERA.

351.

NUTTALL and JEPSON, *loc. cit.*

Simmonds (1892) working at the Old General Hospital in Hamburg, studied the flies which were present in the post mortem room, where many bodies and intestines of persons dead of cholera were lying about. Catching a fly, he was able to isolate cholera vibrics from it in large numbers. Thinking the many flies present might be a source of danger, he caused the corpses to be sewed up, and the autopsy tables to be washed off as soon as possible, with the result that vibrics could no longer be obtained from the flies in the room.

352.

NUTTALL and JEPSON, *loc. cit.*

Uffelmann (1892) allowed two flies to feed on liquefied gelatin cultures of cholera, and after they had been kept an hour and two hours, respectively, in a glass, he made roll cultures with them. The first yielded 10,500, the second only 25 colonies. He placed a fly, similarly infected with cholera in a glass containing sterilized milk which he allowed it to drink. As soon as the fly had finished drinking, he shook the milk, to distribute any organisms which the fly might have introduced, and then placed the milk at 20–21 °C. for 16 hours. After this time had elapsed he made cultures from the milk, and found that one drop of milk yielded 100 cholera colonies.

353.

NUTTALL and JEPSON, *loc. cit.*

Chantemesse (1905) isolated cholera vibrios from the feet of flies 17 hours after they had been contaminated; the conditions under which the experiments were carried out is not stated. He considers that flies play an important part in the spread of cholera.

354.

NUTTALL and JEPSON, *loc. cit.*

Ganon (1908) stated that flies can transmit infection for at least 24 hours after a meal of infective material, and during such a period flies may be carried very long distances in railway carriages. The author was unable to show that the insects could retain the power of infecting for more than four days, as none of those he experimented with lived longer than that period.

FLIES AND TUBERCULOSIS.

355.

NUTTALL and JEPSON, *loc. cit.*

Hofmann in a paper published in 1888 on the spread of tuberculosis through house flies, reported certain observations under natural conditions. He examined flies captured in the room of a tuberculous patient and found bacilli in four out of six flies examined, as well as in fly specks scraped from the walls, door and furniture of the room. Similar observations are reported to have been made by Hayward (1904), Buchanan (1907) and Cobb (1905).

356. Flies and Tuberculosis.

LORD, F. T. *Boston Medical and Surgical Journal*, 151, p. 651–654, 1904.

The recorded experiments show that:

1. Flies may invest tubercular sputum and execrate tubercle bacilli, the virulence of which may last for at least fifteen days.

2. The danger of human infection from tubercular fly specks is by the ingestion of the specks on food. Spontaneous liberation of tubercle bacilli from fly-specks is unlikely. If mechanically disturbed, infection of the surrounding air may occur.

As a corollary to these conclusions, it is suggested that:

3. Tubercular material (sputum, pus from discharging sinuses, fecal matter from patients with intestinal tuberculosis, etc.) should be carefully protected from flies, lest they act as disseminators of the tubercle bacilli.

4. During the fly season greater attention should be paid to the screening of rooms and hospital wards containing patients with tuberculosis and laboratories where tubercular material is examined.

5. As these precautions would not eliminate fly infection by patients at large, foodstuffs should be protected from flies which may already have ingested tubercular material.

357. The Fly and Tuberculosis.

COBB, J. O. Is the Common House Fly a Factor in the Spread of Tuberculosis? *American Med. Jour.* Vol. 9, p. 475–477, Philadelphia, 1905.

Refers to experiments by Hayward and Hoffman showing that tubercle bacilli can be ingested and discharged by the house fly with undiminished virulence. He holds that the bacilli may enter the system through the digestive tract rather than by the lungs. He calls attention to the universal prevalence of house flies about stores of all kinds dealing in human foods, and states that here we have a most prolific source of infection.

FLIES AND ANTHRAX.

358.

NUTTALL and JEPSON, *loc. cit.*

The earliest experiments with anthrax in relation to flies are those of Raimbert (1869) who placed "house flies" and "meat flies" on infected material and afterwards tore off their appendages and inoculated them, with positive results, into animals.

359.

NUTTALL and JEPSON, *loc. cit.*

Davaine (1870) made similar experiments with Musca vomitoria, and with a like result.

360.

NUTTALL and JEPSON, *loc. cit.*

Celli (1888) is responsible for the statement that anthrax bacilli pass, unimpaired in virulence, through the alimentary tract of flies, but it is not clear that he excluded the possibility of there being anthrax spores present in the material upon which he fed his flies.

361.

NUTTALL and JEPSON, *loc. cit.*

Sangree (1899) allowed a wingless fly to walk over a plate culture of anthrax and afterwards upon a sterile agar surface; anthrax colonies subsequently developed upon the agar.

FLIES AND DIPHTHERIA.

362.

NUTTALL and JEPSON, *loc. cit.*

With regard to the dissemination of B. diphtheriæ by flies we find only one reference: Smith (1898), cited by Dickinson (1907), tried the oft-repeated type of experiment by allowing house flies to walk over infected material and then over sterile media. Naturally he obtained a positive result. There is no evidence that under natural conditions flies have anything to do with the spread of diphtheria, but it is, of course, conceivable that they may convey the infection under suitable conditions.

FLIES AND OPHTHALMIA.

363.

HOWARD, L. O. From "The House Fly."

Dr. Lucien Howe of Buffalo is of the opinion that ophthalmia of the Egyptians is also transferred by flies. Dr. Howe called attention to the fact that

the number of cases of this eye disease always increased when the flies are present in the greatest numbers and that the eye trouble is most prevalent in the place where the flies are most numerous.

364.

NUTTALL and JEPSON, *loc. cit.*

Budd as early as 1862, considered that it was fully proven that flies served as the carriers of Egyptian ophthalmia, and Laveran in 1880, writing of Biskra, says the same. These writers also point out that Braun (1882), Demetriades (1894) and German (1896) agree that gonorrheal and other infections of the eye may be carried by flies. Welander (1896) observed an interesting case where an old bed-ridden woman in a hospital became infected. It seems that her bed was alongside that of another patient who had blennorrhea, but that a screen which did not reach to the ceiling separated the beds. Thus all means of infection except through the agency of flies was apparently absent.

Nuttall and Jepson conclude their consideration of ophthalmia with the following statement: "The evidence regarding the spread of Egyptian ophthalmia by flies appears to be conclusive, and the possibility of gonorrhœal secretions being conveyed by flies can not be denied."

ECONOMIC LOSSES CAUSED BY THE HOUSE FLY.

365.

HOWARD, L. O. Economic Loss to the People of the United States through Insects that Carry Disease. *Bureau of Entomology Bulletin*, No. 71, p. 23–36; 7. Washington, 1909.

Malaria, yellow fever, the typhoid fly are shown to retard the progress of nations by great losses in vitality and otherwise.

FLY PREVENTIVES.

366. The Disease Carrying House Fly.

JACKSON, DANIEL D. *American Review of Reviews*, Vol. 42, p. 44–48, New York, 1910.

Among recommendations made by Jackson, are as follows:

We should abolish open privies and properly dispose of our sewage and other waste products.

Our sanitary inspectors in cities should be instructed first to disinfect and then to remove all exposed filth wherever found.

Stable manure should be thoroughly screened or kept in tight, dark receptacles and removed at regular intervals.

Laws should be passed in all our states, as they have been recently passed in several, requiring the thorough screening of all public kitchens, restaurants and dining rooms. All food, particularly that which is eaten uncooked, exposed for sale during the fly season, should be screened. The same care should be taken with all food in the home.

Dealers who allow their food products to be exposed to flies should be carefully avoided.

367. The Dangerous House Fly.

GERHARD, WILLIAM PAUL. *Gesundheits Ingenieur*, No. 52, p. 947, 1910.

In a discussion of control measures, the disinfection of manure heaps, as principal breeding places, with chloride of lime, is recommended.

368.

In the twelfth bulletin of the Bureau of Economy and Efficiency in Milwaukee, it is recommended that the garbage containers should be regularly disinfected and deodorized.

369. Things to be Remembered for the Prevention of Flies.

Pennsylvania State Department of Health Bulletin, No. 32, 1912.

1. Flies can only breed in filth of the kinds mentioned and their presence is evidence that such material is at hand.
2. They carry the cause of disease on their hairy bodies and legs.
3. Keep them away from the sick, particularly those suffering with a communicable disease.
4. Do not allow them to settle on the mouth, eyes, ears or nostrils of infants.
5. Do not permit them to come in contact with food of any kind or to settle on the milk bottles of infants.
6. Open privy wells or cesspools are particularly dangerous. Sanitary closets should be used.
7. Uncovered or unscreened garbage cans and open drains should not be permitted.
8. Physicians should see that the excreta of all persons ill with intestinal disease are disinfected and cared for in accordance with the regulations of this department.
9. Manure should be collected twice a week and spread on the fields and composted or stored in fly-proof receptacles.

FURTHER BIBLIOGRAPHICAL REFERENCES ON THE HOUSE FLY.

370.

NUTTALL, GEORGE H. F. and JEPSON, F. P. The Part Played by Musca Domestica and Allied (Non-Biting) Flies in the Spread of Infective Diseases. Reports to the Local Government Board of England and Wales on Public Health and Medical Subjects. (New Series No. 16.) London, 1909.

Frequent Reference to this valuable source of information is made under the heading "Nuttall and Jepson."

371.

HOWARD, L. O. The House Fly, Disease Carrier; an Account of its Dangerous Activities and of the Means of Destroying It. New York, 1911, 312 p.

The book on the House Fly by Dr. Howard, director of the U. S. Bureau of Entomology, is a standard work on this important subject.

372.

HEWITT, C. GORDON. The House Fly, Musca Domestica. A Study of its Structure, Development, Bionomics and Economy. Manchester, 1910, 195 p.

373.

HERMS, WILLIAM B. The House Fly in its Relation to Public Health. *California Agric. Exp. Station Bull.* No. 215, Sacramento, 1911.

374.

TERRY, C. E. Extermination of the House Fly in Cities, its Necessity and Possibility. *Am. Jour. Public Health,* Vol. 2, p. 14–22, New York, 1912.

375.

FELT, E. PORTER, State Entomologist. Twenty-fourth Report of the State Entomologist on Injurious and Other Insects of the State of New York. Albany, N. Y., 1909.

Contains a good bibliography to which we owe much valuable information, sometimes inserted literally into our references.

376.

GORGAS, COL. WILLIAM C. Sanitation of the Canal Zone. *Medical Record,* Vol. 73, No. 7, New York, 1908.

BACTERIA IN STREET DUST.

377. Quantitative Study.

WINSLOW, C.-E. A. and KLIGLER, I. J. A Quantitative Study of the Bacteria in City Dust with Special Reference to Intestinal and Buccal Forms. *Am. Jour. of Public Health,* Vol. 2, p. 663–701, New York, 1912.

An exhaustive review of the field precedes the important and comprehensive work undertaken by the authors.

The indoor dusts (house, school and vacuum) were generally under 20,000,000, the street dusts usually over 20,000,000. The average for house dusts was 5,500,000, for vacuum dusts 3,730,000, for school dusts, 4,790,000 and for street dusts 49,200,000 germs per gram of dust.

From the "Summary" parts of paragraphs 1, 8, 9 and 10 are here cited:

1. The total number of bacteria in city dust as determined by plating on lactose agar at 20° is high, ranging from 150,000 to 145,000,000 per gram. There is a marked difference between street dusts and those collected indoors. Street dusts were found to be usually over 20,000,000 and 24 samples averaged 49,200,000. The 72 indoor dusts were usually under 20,000,000 and averaged between 3 and 5 millions. . . .

8. Actual isolations of non-spore-forming disease bacteria from dust have

been confined almost wholly to a few findings of B. diphtheriæ, and many findings of the tubercle bacillus and of streptococci and diplococci more or less closely resembling the pneumococcus. Isolations of the tubercle bacilli are by far the most significant. They indicate that this organism may sometimes be found in 5% to 10% of samples of dust not specially exposed to tubercular infection, while in the neighborhood of phthisical patients 25% to 50% of the tests may prove positive. The experiments of Prausnitz (1891), Verdozzi (1908) and LeNoir and Camus (1909) suggest that B. tuberculosis may be present in numbers ranging from 5 to 20 per gram of dust.

9. . . . If the dust contains 40,000 mouth streptococci, as our results indicate that it may, and if tubercle bacilli are present as often as other workers have found to be the case, inhaling and ingesting large quantities of dust may have a real sanitary significance.

10. While suggesting that dust inhaled or ingested in considerable quantities may be a real factor in the spread of certain diseases, we do not in any way dissent from the conclusion now generally accepted by sanitarians that in comparison with more or less direct contact and food infection it is quantitatively a minor one.

378. Traffic and Bacteria.

Report, II. International Road Congress, Brussels, 1910. Section I, No. 35.

The influence of wind and increased traffic on quantities of floating, living matter in an ordinary city street, was shown in the results of some interesting recent experiments by the Municipal Bacteriological Institute of the City of Budapest.

Agar plates were exposed in the street under various conditions for periods of 15 minutes.

The plates were then placed in a thermostat, and the colonies of microbes thus developed at a temperature of 38°C. were counted.

I. Experiment: Inconsiderable vehicular traffic; dry weather; moderately strong wind.

	Colonies of germs.
A. On exposed plate which lay on the road surface	345
B. On a plate exposed at a height of 50 cm.	45
C. On a plate carried about by a pedestrian	445

II. Experiment: All other conditions as above, but no wind.

A. As above	12
B. As above	7
C. As above	24

III. Experiment: The plates exposed were driven about in a carriage during exposure, therefore, the movement was quicker than in the cases of "C" above.

Six experiments were made, all showing a great many more colonies of microbes: 1268, 2204, 1660, 7200, 1400, 4500.

379. Factor in Spreading Disease.

ANDERS, JAMES M. Street Dust as a Factor in Spreading Disease; Methods of Removal. *Medical Record,* Vol. 78, p. 563–566, New York, 1910.

380. Dust in the Atmosphere.

FRIESE, WALTHER. Der Staub- und Russgehalt der Luft in Dresden. *Deut. Vierteljahrsschr. f. öffentl. Ges. Pfl.* Vol. 44, p. 201–234. Braunschweig, 1912.

381. Dust and Fume, Foes of Industrial Life.

OLIVER, SIR THOMAS. Address delivered at the International Congress of Hygiene and Demography, Washington, 1912. *Lancet,* 1912, II, p. 865–871, London.

382. Bacteria in Daily Life.

FRANKLAND, MRS. GRACE C. T. London, 1903. 216 p.

383. Dust Menace and Municipal Disease.

ANDERS, H. S. *Jour. Am. Med. Assn.* Vol. 57, p. 1524–1526, Chicago, 1911.

384. Dust and Its Danger to Children.

LA FÉTRA, LINNAEUS EDFORD, *Archives of Pediatrics,* Vol. 23, p. 869–872, New York, November, 1906.

DUST IN CONNECTION WITH INFANTILE PARALYSIS AND MENINGITIS.

385. Poliomyelitis from Sickroom Dust.

NEUSTAEDTER, M. and THRO, WILLIAM C. Experimental Poliomyelitis, produced in Monkeys from the Dust of the Sickroom. *New York Medical Journal,* Vol. 94, p. 613–615; 813–820, New York, 1911.

386. Infantile Paralysis is a Dust Disease.

N. Y. Times, October 11, 1911. This has reference to the above work of Messrs. Neustaedter and Thro.

387. Epidemic of Poliomyelitis.

CAVERLY, DR. CHARLES S., President State Board of Health. Report on the Epidemic of Poliomyelitis in Vermont during 1911.

Flexner and Clark have confirmed by recent animal experiments the fact that the virus is present in the tonsils and pharyngeal mucosa of human beings who succumb to the disease.

Hence all discharges from nose and throat of patient should be destroyed and constant care be exercised in cleansing the naso-pharynx.

388. Apparent Factor in Spread of Poliomyelitis.

Dust as an Apparent Factor in Spread of Poliomyelitis. From the biennial report of the Minnesota State Board of Health, 1909–1910, p. 202.

A prolonged investigation was made, involving visits to 33 places in the state, together with side trips from many of these. Every case seen was investigated clinically and epidemiologically.

At Winona, the investigation showed practically all the existing cases were on or near unwatered and very dusty streets. The city was panic stricken and my advice transmitted and reinforced to the city council by Dr. Donald Pritchard, H. O. of Winona, together with a map on which the cases were plotted, showing their relation to the watered and unwatered streets, resulted in securing the watering of these streets as well as the watering of sidewalks, etc. The watering began August 5 and the last case developed August 12. When it was remembered that the incubation period of this disease is supposed to be about seven days, it will be understood that no case received infection *after the watering began.* Since the district surrounding Winona and the state at large continued to suffer the disease for months after this date (the outbreak reaching its height a month later), it seems not unreasonable to suppose that the ending of the Winona outbreak when the watering began was not merely a coincidence, especially since Eau Claire and New Richmond in Wisconsin had previously had similar experiences.

389. Epidemic at Springfield.

Sheppard, Philip A. E. A study of the Epidemic of Acute Poliomyelitis at Springfield, Mass. *Bulletin* No. 3, of the Vermont State Board of Health, March, 1912.

Springfield constituted the largest epidemic focus in Massachusetts.

Dr. Sheppard, who was the special medical examiner for the Massachusetts State Board of Health, regarding this Springfield epidemic of infantile paralysis, states that: The majority of cases occur near railroads and along the lines of greatest travel and that dust has to a certain extent figured in every case.

390.

From Studies in Infantile Paralysis during 1910, published by the Washington State Board of Health.

A considerable number of factors might possibly be advanced as having a possible relationship to the increased prevalence of infantile paralysis at this period of the year. The three that have received the most attention have been:

1. *Insects.* It has been suggested that since the season of greatest prevalence of infantile paralysis corresponds, approximately, to the season of the maximum prevalence of many insects, that, therefore, it may be that the disease is transmitted through insect bites. This theory will have to fulfill many

difficult requirements before it can be very seriously urged, unless it can be corroborated as a result of laboratory experiments. The findings of Flexner that the virus can be retained for at least 48 hours in a negative condition by a fly's foot, are highly suggestive in this respect.

2. *Dust.* Hill, of Minnesota, has been an active advocate of this theory. It is very suggestive at least to note that the outbreak in this state occurred during a season of unusually deficient precipitation of rain. Owing to the fact that the summer season is a period of almost total absence of rainfall in the coastal region, as well as in the eastern division of Washington, the theory that dust is an active means of conveying the infected virus is practically reconcilable to the climatological data of this state.

3. *Travel.* Richardson and Lovett have argued that the increase in travel in the summer months may explain the greater prevalence of infantile paralysis during this season. It is also easily conceivable how this factor plays an important part in the transmission of the disease in this state, since there is an ever-increasing amount of travel by tourists, expecially from the Middle West to the region of Puget Sound. These tourists begin to arrive about midsummer. Local traffic in the state is decidedly more active in the dry season than in the rainy. Especially is it true that there is a very considerable movement of people from the semi-arid region of the eastern sections to the coast during the heat of the summer season.

391.

Municipal Journal, Vol. 32, p. 287, 1912.

On account of a few cases of meningitis at Justin, about eight miles west from Roanoke, Tex., a day was set apart, as a result of the mayor's proclamation, for cleaning the town. Everybody got busy and worked all day, and the meningitis scare has subsided.

392.

Municipal Journal, Vol. 32, p. 485, 1912.

At the recent meeting of county and city health officers at Oklahoma City, Okla., it was agreed that while the disease is only slightly contagious, dust and garbage demand special attention in securing prevention; where paved streets were swept by machinery, they should be flushed with water. Of the 250 cases in Oklahoma, but five or six were traceable to contact with victims.

393.

Municipal Journal, Vol. 32, p. 247, 1912.

The State Health Department having received official confirmation of a number of meningitis cases, some resulting fatally in adjoining counties, it has been arranged by the City Health Department of Oklahoma, Okla., to conduct a general clean-up.

394.

The clean-up week in Washington, D. C. (April, 1912), brought into action much great and good sense as shown in the hearty coöperation of the people, who awoke to the realization that their surroundings left much to be desired.

A singular fact in connection with the crusade was that the worst places found by the investigators were not in the slums, but in the better section of the city.

There has been a large increase in the quantity of rubbish hauled by the city contractors to the public dumps.

A newspaper kept a corps of photographers busy making pictures of dirty alleys, back yards, etc., and no sooner were the pictures printed in the newspaper than the owners of the property began to clean up.

STREET FLUSHING AND CLEANING.

395. Modern Methods of Street Cleaning.

SOPER, GEORGE A. New York, Engineering News Pub. Co., 1909, viii, 291 p. 8°.

For street sprinkling and flushing, chloride of lime is used in London, England.

The vans are fitted with especially made jars, which allow the bleach solution to escape gradually.

At Poplar, the sodium hypochlorite solution, made by the municipality, is used; one part of the solution diluted with 200 parts of water.

From Kershaw's data on the Poplar Installation, *Jour. Soc. Chemical Ind.*, Vol. 31, p. 54–57, 1912, we calculate that

1000 U. S. gallons of the liquid for sprinkling will cost.............	$0.06
An equal volume made from chloride of lime would cost..............	.01
An equal volume made from sanitas would cost....................	.10

396. The Dust Problem in Road Cleaning.

ANDES, L. E. Die Beseitigung des Staubes aus Strassen und Wegen, etc. (The Dust Problem in Road Cleaning.) *Hartlebens Technische Bibliothek*, No. 313. Wien 1908.

397. House-Sweepings and Road-Dust.

DOERR, CLEMENS. Hausmüll und Strassenketrieht. (House-Sweepings, Dust from City Roads.) Leipzig, 1912, 496 p.

398. Tests in Street Flushing.

VERY, E. D. Tests of Street Flushing or Washing Machines, Department of Street Cleaning, New York City. *Engineering News*, Vol. 63, p. 420–422, 1910.

Out of 24,200,000 square yards of area, under the jurisdiction of Commis-

sion of Street Cleaning, it has been proposed to clean by flushing 17½ millions of square yards. One square yard consumes for one flushing approximately 1½ gallon by hose flushing from the hydrant, and .05 gallon by wagon flushing, which would not make more than 8 to 25 million gallons per day.

399. Altoona, Pa.

Municipal Journal, Vol. 32, p. 491, 1912.

Advantages in economy are reported from Altoona, Pa., of machine flushing over hydrant flushing. For labor the department had to pay $11.50 when working with hydrants, while it costs only $2.60 to operate the flusher to the same effect. Also much less water is consumed.

400. Town Scavenging and Refuse Disposal.

Watson, Hugh S., London [1911].

In the London metropolitan boroughs, where ordinary water is used, a disinfectant of some description is generally added to it. This either takes the form of sanitas or kuma pine blocks or a weak solution of either carbolic or permanganate of potash. The sanitas blocks cost 1 *s.* each, and one will generally be sufficient for about 2,000 gallons of water.

The methods which have been in use at Poplar for the past two or three years for producing a cheap, and at the same time powerful disinfectant by means of hypochlorite, are worthy of attention. Dr. Klein, bacteriologist to the Local Government Board, has certified that one ounce of the fluid to 150 ounces (nearly one gallon) of water will kill the cholera germ in two and one-half minutes. Experiments have shown that diluted 200 times, this disinfectant forms a suitable and effective solution for road watering.

401. Sanitation and the City.

Baskerville, Charles, Ph.D., F.C.S., Professor of Chemistry and Director of the Laboratory, College of the City of New York. Municipal Chemistry, p. 13.

"We may minimize spitting, but we can not stop it. The streets should therefore be either made dustless or wet down with dilute chlorine water, that is, a solution of bleaching powder, or other disinfecting fluid."

DISINFECTION.

402.

Rideal, Dr. Samuel. Thorpe's *Dictionary of Applied Chemistry*, 2d Ed. Vol. 2, London, 1912.

A disinfectant is an agent that will kill lower organisms which act injuriously on higher forms of life.

Disinfectants are germicides.

Antiseptics may only retard or inhibit the growths.

It is not essential for a disinfectant to effect absolute sterility; in practical disinfection, there is nearly always a residue of highly resistant and non-pathogenic organisms.

To destroy these involves great additional time and cost and may even be disadvantageous when they act as natural scavengers in removing objectionable organic matter and antagonostic dangerous forms.

The choice of an agent will obviously depend on considerations of safety, convenience and economy in use.

403.

RIDEAL, DR. SAMUEL. Germidical powers expressed in terms of 100=carbolic acid. Thorpe's *Dictionary of Applied Chemistry*, Vol. 2, London, 1912.

Carbolic acid	100
Absolute alcohol, less than	10
Acetic acid	60
Benzoic acid, about	50
Boric acid, less than	10
Chlorine water	2,800
Copper sulphate (calcul. as $CuSO_4$)	200
Cresylic acid, commercial	370
Eucalyptol	120
Formaldehyde	70
Formic acid	570
Hypochlorites (calculated as chlorine)	14,600 to 22,000
Iodine water	10,000
Bromine water	6,400
Iodine trichloride	9,400
Zinc chloride	15
Lactic acid	180
Potassium permanganate	4,200
Hypochlorites with 50% urine	800
Cadmium chloride	155
Cadmium sulphate	100
Chinosol	15 to 30
Guaiacol	90
Hydrochloric acid	158
Pyrogallic acid	22
Resorcin	30
Silver nitrate	1,580
Sodium bisulphate	410
Mercuric chloride *	40,000 to 354,000

* The extremely high values once given for mercuric chloride were due to the powerful inhibitory action of the traces carried over with the sub-cultures in the inoculations.

404.

Only the non-spore-forming bacteria are destroyed by minute doses of hypochlorites, which do not kill spores. In a similar manner, vegetative germs succumb at temperatures above 70°C., while spores are not injured, and can even resist the temperature of boiling water, 100°C., for a short time.

The following table illustrates this low resistance of vegetative pathogenic germs:

Pathogenic germs.	Temp.	Time, minutes.	Observer.
Cholera spirillum	52°C.	4 m.	Sternberg
B. typhosus	56°	10 "	Sternberg
B. dysenteriæ	68°	20 "	McFarland
B. influenzæ	60°	5 "	McFarland
B. tuberculosis	60°	20 "	Rosenau
Staphylococcus pyogenes	62°	10 "	Sternberg
Staphylococcus pyogenes aur	80°	1½ "	Sternberg
Streptococcus	52–56°	10 "	Sternberg
Pneumococcus pathogenesis	52°	10 "	McFarland
B. coli	60°	10 "	McFarland
B. diphtheriæ	58°	10 "	Abbot
B. Icteroides	60°	few "	McFarland
B. Influenzæ	60°	5 "	McFarland

405.

Disinfection and Disinfectants: Their Application and Use in the Prevention and Treatment of Disease, and in Public and Private Sanitation. American Public Health Association. Concord, N. H., 1888, 266 p.

406.

Rideal, Samuel. Disinfection and Disinfectants. (An Introduction to the Study of). Together with an account of Chemical Substances used as Antiseptics and Preservatives. 3d Ed. London, 1903.

407.

Hewlett, R. Tanner. Disinfection and Disinfectants; the Milroy Lectures. *Lancet*, Vol. 176, p. 741–745, 815–821, 889–894, London, 1909.

408.

La Pratique de la Désinfection Publique et privée en France. (Disinfection, Public and Private, as practised in France.) *Revue d'Hygiene et de Police Sanitaire*, Vol. 28, p. 1009–1042; Vol. 29, p. 289–293. Paris, 1906–07.

409.

Instructions for Disinfection. New York State Department of Health, *Circular*, No. 16.

410.

ANDREWES, F. W. Lessons in Disinfection and Sterilization: An Elementary Course of Bacteriology, together with a Scheme of Practical Experiments, Illustrating the Subject-Matter. London, 1907, 2d Ed. 222 p.

Professor Andrewes who is pathologist and sanitary officer to St. Bartholomew's Hospital, London, gives a brief but comprehensive account of great value which will be appreciated by everybody interested in sanitary matters.

411.

CORNIL, FRANCOIS and DEVILLE, VICTOR. Traité de Désinfection. Historique, Généralités, Législation, Agents, et Appareils, Contrôle, Pratique de la Désinfection, Désinfection Municipale et Départementale, Stations de Désinfection. (Treatise on Disinfection, Historical, General, Legislation, Disinfectants and Apparatus, Testing, Municipal Disinfection, Disinfecting Stations.) Paris, J. Rousset, 1911. 647 p.

412.

McFARLAND, JOSEPH. Pathogenic Bacteria and Protozoa. Philadelphia and London, 1912.

413.

SCHNEIDER, ALBERT. Pharmaceutical Bacteriology, with Special Reference to Disinfection and Sterilization. Philadelphia, 1912, 238 p.

STANDARDIZING OF CHEMICAL DISINFECTANTS.

414.

A lucid exposition and historical survey of the methods for standardizing disinfectants by PROF. SHERIDAN DELÉPINE has recently been published in the *Journal of the Society of Chemical Industry*, Vol. 30, p. 334–343, London, 1911, from which the following brief extracts are made:

Bacterial standardization of chemical disinfectants was practised much on present lines and described in detail by Dr. Baxter in the Report of the Medical Officer of the Privy Council and Local Government Board. (New Series No. 6, 1875).

Dr. Baxter describes his method as follows:—"A known quantity of the agent under investigation was added to a liquid teeming with septic microzymes. A test solution (Cohn's solution without calcium phosphate) previously sterilized by heat was then inoculated with a minute drop of the disinfected liquid. It is continued barren, the successful destruction of the septic germs was proved, in the event of their incomplete destruction the test liquid was found crowded with their progeny."

The detailed description given by Dr. Baxter shows that he conducted

his opèrations very much in the same way as we conduct them at the present time, when we test disinfectants by the suspension method.

He was surprised to find that "the microzymes which swarm in Cohn's solution" were completely deprived of reproductive power by:—

Chlorine, when in the proportion of 0.0008% or more, *i. e.*, a 1:125,000 dilution.

Potassium permanganate, when in the proportion of 0.007% or more, *i. e.*, a 1:14285 dilution.

Sulphur dioxide when in the porportion of 0.123% or more, *i. e.*, a 1:183 dilution.

Carbolic acid, when in the porportion of 1% or more, *i. e.*, a 1:100 dilution.

He also made inoculation experiments with disinfected vaccine lymph and found the following proportions of the disinfecting agents required for rendering lymph inactive:

Chlorine when present	1 in 612
Potass. permanganate	1 in 200
Carbolic acid	1 in 50

Further tests with exudations from cases of septic peritonitis and with emulsions obtained from glanders, nodules were likewise based on inoculations with the disinfected virus.

Since 1881, under the influence of Koch's work, the use of pure cultures has been adopted almost by every worker, and there can be no doubt as to the advantage of using pure cultures when accurate comparisons have to be made.

Koch's method:—He employed small quantities of pure cultures of test organisms and large quantities of the disinfecting fluid, the action of which was tested after various intervals.

Koch impregnated short silk threads with anthrax spores, dried the threads and placed them into disinfecting solutions of known strength, from which the threads were removed after various intervals and then transferred directly to some solid medium, Koch being under the impression that the use of solid media was essential for working with pure cultures.

1889–1890. Fraenkel and Behring, instead of transferring to solid media, transferred the infected threads to peptone bouillon, opining that the bacteria often carried enough disinfectant with them, even after washing, to prevent their growth on solid media.

1897. Kroenig and Paul, instead of silk threads, loaded sterilized Bohemian garnets with the pathogenic spores and germs (anthrax and straphylococcus). After immersion into the disinfecting fluids and washing, etc., the germs were removed from the garnets by shaking with water and incubated with agar. The bacteria used for infecting the garnets were obtained from agar cultures and suspended in water and were therefore practically free from extraneous organic matter.

1880. Sternberg gives in his classical manual of bacteriology a general review of the subject. The method he recommends for testing disinfectants resembles closely that used by Dr. Baxter, with this difference that Stern-

berg employed pure cultures, and paid more special attention to the duration of exposure.

He describes as follows the method which he adopted in 1880:—

"The time has been constant—usually two hours—and the object has been to find the minimum amount of various chemical agents which would destroy the test organism in this time. . . . A certain quantity of a recent culture, usually 5 cc., has been mixed with an equal quantity of a standard solution of the germicidal agent. Thus 5 cc. of a 1 to 200 solution of carbolic acid would be added to 5 cc. of a recent culture of the typhoid bacillus, for example, and after two hours' contact one or two loopfuls would be introduced into a suitable nutrient medium to test the question of disinfection. In the case in question the results obtained would be set down as the action of carbolic acid in the proportion of 1 to 400."

Wynter Blyth, in 1886, replaced ordinary culture by emulsions of bacteria made with distilled water, thus reducing the amount of associated organic matter to a minimum. Measured quantities of such emulsions were then added to known quantities of disinfecting solution of known strength, and after a given time, a drop of the mixture was transferred to melted gelatine.

The drop method was in 1903 modified by Rideal and Walker, who indicated an arrangement for making parallel series of exposures of the bacillus typhosus to the action of various dilutions of two disinfectants, one of which (carbolic acid) was taken as standard.

Rideal and Walker's method as described by these two chemists in their original communication is conducted as follows:—"To 5 cc. of a particular dilution of the disinfectant in sterilized water add 5 drops of a 24 hours blood-heat culture of the organism in broth, shake and take sub-cultures every 2½ minutes up to 15 minutes. Incubate these sub-cultures for at least 48 hours at 37° C. Allowing 30 seconds for each act of medication and the same time for making each sub-culture, four different dilutions of the disinfectant under examination, together with one standard control may be tested against the same culture, under conditions which make the results strictly comparable. If preferred, the field may be extended and divided into intervals of five minutes, but we contend that no table is complete which does not show a positive result in the first column, and a negative result in the last. The strength of efficiency of the disinfectant is expressed in multiples of carbolic acid performing the same work, *i. e.*, when we have obtained a dilution of the disinfectant which does the same work as the carbolic acid dilutions, we divide the former by the latter, and so obtain a ratio which we call the "Carbolic acid coefficient."

It will be seen that Rideal and Walker do not remove associated organic matter as thoroughly as Wynter Blyth or Kroenig and Paul, but they reduce it so considerably as to deprive it of all importance.

Delépine's suspension method resembles closely some of the methods used by Baxter and Sternberg. The time of exposure is equal in all cases, and other factors are likewise rendered as constant as possible; the only variant being the strength of the disinfecting solution.

Delépine directs how to obtain pure typical cultures of definite age, which are used in the testing as follows:

A. Dilutions of disinfectants are accurately prepared.

B. 9 cc. of each of the dilutions are accurately measured in a series of sterilized capped glass capsules.

C. 1 cc. of the test culture is added to the contents of the capsule; thoroughly mixed by shaking.

D. After an interval of time, the same for all dilutions, two loopfuls are removed and transferred into corresponding glass capped tubes containing 6 cc. each of peptone bouillon (+5).

E. The bouillon tubes are then incubated for 48 hours at the same temperature as that at which the original cultures had been incubated.

F. At the end of 24 and 48 hours, the tubes are examined for evidence of growth.

Delépine's Thread Method has been described by him at the request of the committee appointed by the Royal Sanitary Institute in Vol. 28 (1907) of its *Journal.*

Closely twisted silk threads, 2 cm. long are sterilized and charged with B. typhosus by soaking in the freshly prepared emulsion for 15 minutes. The threads are dried (rapidly at 37° C.) and kept in a dark place.

Two impregnated threads are placed into each dilution of the disinfectants, at a temperature of 20° C.

After ten to twenty minutes exposure, the arrest of the action of the disinfectant is rapidly effected by washing the threads in a definite volume of sterilized distilled water.

The threads are then transferred into capped tubes, containing 6 cc. of peptone bouillon. Incubation at 37° C.

They are examined at the end of 24 hours and again at the end of 48 hours, and any evidence of growth noted each time.

Delépine points out that the thread method is the only one that can conveniently be used to test practically the value of disinfectants intended for the disinfection of surfaces, or of articles contaminated with infectious products, also that the thread method is the one indicated for the study of the action of gases, vapors, and sprayed fluids, when the primary association of the water with the best organism would vitiate the results by introducing an element which is not present in actual practice.

415.

Partridge, William. The Bacteriological Examination of Disinfectants. London, 1907, 66 p.

416.

Delépine, S. The Standardizing of Disinfectants. *Jour. of the Roy. Inst. of Public Health,* Vol. 16, p. 577–595, London, 1908.

417.

CHICK, HARRIETTE and MARTIN, C. J. The Principles Involved in the Standardization of Disinfectants and the Influence of Organic Matter upon Germicidal Value. *Jour. Hygiene,* Vol. 8, p. 654–703, Cambridge, Eng., 1908.

418.

ANDERSON, JOHN F. and MCCLINTIC, THOMAS B. Method of Standardizing Disinfectants with and without Organic Matter. *Hygienic Lab. Bull.* No. 82, 34 p., Washington, 1912.

Very valuable as it gives the carbolic acid coefficient of 49 disinfectants, mostly of American origin.

HYPOCHLORITES IN PRESENCE OF ORGANIC MATTER—USES.

419.

RIDEAL, S. Influence of Organic Nitrogen Compounds on Chlorine Disinfection. *Journal of the Royal Sanitary Institute,* Vol. 31, p. 33–45, London, 1910.

In these important studies, Dr. Rideal throws much light on the "Residual Chlorine" and its function in water and sewage disinfection.

The formation of chloramines by the action of the hypochlorites on albumens and other organic nitrogen compounds, is shown.

In dilute solutions the Rideal-Walker coefficient of 2.18 for 1% available chlorine is increased to 6.36 by the addition of an equivalent of ammonia, remains near this level for 24 hours and even after 72 hours has an enhanced value.

Therefore, since the coefficient of chlorine itself averages 220 units, that of ammonia less than 0.7 and ammonium chloride *nil,* that of the chief product, chloramine NH_2Cl must be over 600 units, hence this substance, but for its instability would probably be the most valuable of disinfectants.

It has a pungent odor, hitherto often mistaken for chlorine or hypochlorous acid and gives the blue reaction with potassium iodide starch.

With excess of ammonia, as in sewages, it gradually disappears, forming a salt of hydroxine, which still has a germicidal value (Rideal-Walker coefficient of the base at least 24).

The action of chlorine on nitrogenous compounds gives compound chloramines, many of which are insoluble, they have a tendency to become fixed on cellulose and in this way they attack the envelops of germs.

Table showing the increased germicidal efficiency in presence of ammonia: Test organism, B. typhosus broth culture 24 hours at 37.5° C. Sub-cultures incubated 48 hours at 37.5° C.

Temp. 17° C.			
Available chlorine.	Time culture exposed to action of disinfectant, minutes.		
	5	10	15
Sodium hypochlorite, 1/24,000	+	–	–
Same with equal of ammonia 1/46,000	–	–	–
Same with equal of ammonia 1/50,000	–	–	–
Same with equal of ammonia 1/70,000	+	–	–
1/110 Carbolic acid	+	–	–
1/120 Carbolic acid	+	+	–

This great increase of germicidal efficiency through presence of ammonia gave to Rideal the key to further important results and conclusions.

In presence of an equivalent of urea the disinfecting value of hypochlorites was still maintained on par.

In presence of urine (the hypochlorite had been in contact with a urine diluted 1 to 5 in water for 30 minutes previous to infection with the test bacillus) the original disinfecting value had become only lowered by $\frac{1}{25}$; the remaining 96% efficiency standing to the account of organic chloramines of superior germicidal powers. This indicates that the action of the hypochlorites on those bodies was not entirely an oxidizing one and it must be concluded that in a similar manner the plasmatic albumens of the bacteria are affected.

The germicidal action of hypochlorites can no longer be explained as a process solely of oxidation, and inasmuch as chlorine appears to form substituted chloramines quite readily, we must concede to the halogene some of the corresponding disinfecting merits.

420.

Andrewes, F. W. Resistance of Organic Matter to Hypochlorous Acid. *Lancet*, 1905, II, p. 1106, London.

Draws attention to the fact that solutions of hypochlorous acid, in the presence of much organic matter, are comparatively inert to the same.

421.

Clayton, G. C. Efficiency of Hypochlorites in Presence of Albumens, etc. *Jour. Soc. Chem. Industry*, Vol. 15, p. 320–322, 1896.

Gives extracts from investigations by Professor Boyce, on efficiency of sodium hypochlorite in presence of albumen. Experiments with putrefied egg and broth solution showed that the sterilization was effected by $\frac{1}{2}$% available chlorine, while $\frac{1}{10}$% available chlorine killed all organisms except the hay bacillus.

Chloride of lime and sodium hypochlorite have a great advantage over

corrosive sublimate, carbolic acid and the numerous cresol disinfectants, in that the chlorine compounds dissolve albumen instead of precipitating it thereby helping to disintegrate solid fecal matter which is so necessary for sterilization. Sodium hypochlorite solution of 1% available chlorine strength, dissolved white of egg readily with liberation of chlorine.

422.

From the *U. S. Dispensatory*, 19th Ed. 1910, p. 269–270.

Chlorinated lime, externally applied, is a desiccant and disinfectant, and has been used with advantage in solution, as an application to ill-conditioned ulcers, burns, chilblains and cutaneous eruption, especially itch; as a gargle in putrid sore throat; and as a wash for the mouth to disinfect the breath, and for ulcerated gums. For the cure of itch, Derheims has recommended a much stronger solution—three ounces of the chloride of lime to a pint of water, the solution being filtered, and applied several times a day as a lotion, or constantly by wet cloths. When applied to ulcers, their surface may be covered with lint dipped in the solution. When used as an ointment to be rubbed on scrofulous enlargements of the lymphatic glands, this may be made of a drachm of the chloride to an ounce of lard. Chlorinated lime is less eligible for some purposes than the solution of chlorinated soda.

The cost of bleaching powder for use in quantities is so slight that even a saturated solution may be prepared for use in the sickroom at a nominal cost. For the destruction of disease germs in urine, fecal discharges, sputa, etc., a saturated solution of bleaching powder appears to be in all respects the best disinfectant known. As it is important to destroy the germs as soon as possible, this solution should be put into receptacles to be used by the patient before the discharges are ejected into them. As the chlorinated solution attacks metals, the spit cups, etc., should be china or glass.

In consequence of its power as a disinfectant, chlorinated lime is a very important compound in its application to medical police. It may be used with advantage for preserving bodies from exhaling an unpleasant odor, before interment in the summer season. In juridical exhumations its use is indispensable, as it effectually removes the disgusting and insupportable fetor of the corpse. The mode in which it is applied, in these cases, is to envelop the body with a sheet completely wet with a solution made by adding about a pound of the powder to a bucketful of water. This solution may also be employed for disinfecting dissecting rooms, privies, common sewers, docks, and other places with offensive effluvia.

423.

From the *U. S. Dispensatory*, 19th Ed. 1910, p. 737.

Solution of chlorinated soda possesses the medicinal properties of chlorinated lime, *i.e.*, dependent on its available chlorine. Formerly it was used internally in various conditions of adynamia and zymosis; it is, however, at present rarely so given. As a local remedy it is very actively stimulant and antiseptic, and

has been used to a considerable extent not only in the treatment of external infected wounds and ulcers, but also in infected conditions of the vagina, uterus, bladder, mouth, fauces, and other cavities which can be reached from the outside. Usually in these cases it should be diluted with from 15 to 30 parts of water, and when it is employed in indefinite quantity, as in washing out the bladder by means of the double canula, half an ounce is sufficient in one and a half pints of water. When used by means of lint or in other ways for the treatment of skin eruptions, the dilution should contain from 10% to 30%.

424.

SCHUMACHER, DR. Disinfection of Typhoid Dejecta with Chloride of Lime. *Gesundheits Ingenieur,* Vol. 28, p. 363, Munich, 1905.

Nissen, came to the conclusion that 2%, also 1% and even ½%, of chloride of lime applied in form of powder produced disinfection within 2 minutes. For general practice, he recommends one gram chloride of lime for 100 grams feces.

Sternberg advises to use for each dejection 200 grams of a 3% solution; this quantity has been increased to 400 grams by the American Public Health Association.

425.

RIDEAL, DR. S. *In* Disinfection, p. 447, states:

The following solution of chloride of lime is used in the British Military Stations:

Dissolve 4 oz. of chloride of lime in 1 gallon of soft water. Use 1 pint of this solution for disinfection of the excreta in cholera, enteric fever, etc. All discharges should be left in contact with this disinfectant for 10 minutes before final disposal.

426.

Bleaching Powder as a Substitute for Soap. *Scientific American Supplement,* Vol. 73, p. 304, New York, 1912.

Dr. G. F. Sacher, in an article in *Soziale Medizin u. Hygiene,* recommends the use of bleaching powder as a cleansing agent for the hands of the working man as a preventive against metal poisoning. Workmen handling metals, such as lead, mercury, antimony, arsenic, bismuth, zinc, chromium or manganese, either in metallic form or in the form of compounds, are constantly exposed to the danger of poisoning, through imperfectly cleaned hands. Small particles may thus be transmitted to the mouth in eating or smoking. To completely remove metallic impurities from the hands is not always an easy matter; soap alone is in most cases well nigh useless as it forms insoluble compounds with most of the metals. Bleaching powder, however, is an ideal material for the purpose stated. It has no injurious effects on the hands or the blood and may, therefore, be used even on chapped hands. It forms a lather like

soap and acts chemically as well as mechanically, thus removing any metallic impurities or compounds in the shortest time possible. It further has the advantage over soap of having strong disinfecting properties.

FURTHER EVIDENCE ON GERMICIDAL STRENGTH OF CHLORIDE OF LIME.

427. Germicidal Strength of Chloride of Lime.

Disinfection and Disinfectants: Their Application and Use in the Prevention and Treatment of Disease, and in Public and Private Sanitation: *American Public Health Association*, Concord, N. H., 1888, 266 p.

In the report of the Committee on Disinfectants appointed by the American Public Health Association, 1887, General Sternberg, who was chairman of the Committee, says: The comparative cheapness of chloride of lime and its efficiency as a disinfectant, as shown by extended experiments made under the writer's direction in 1885 induced the Committee on Disinfectants to give to this agent the first place among chemical disinfectants.

428.

Delépine, Prof. Sheridan. Results of Tests applied simultaneously to Seven Disinfectants. *Jour. Soc. Chem. Industry*, Vol. 29, p. 1350, London, 1911.

A. Thread Method.

Test microbe B. typhosus grown for 48 hours on peptone bouillon agar (+5) at 37° C. Solution of phenol prepared with distilled water two threads 2 cm. long in 10 cc. of phenol solution.

Tem., 17° C. Time of exposure, 20 minutes.

	Minimum lethal dil. observed.		Maximum non-lethal dil. observed.	
		Parts per 100,000.		Parts per 100,000.
Boric acid	....	....	1-20	5,000
Phenol	1-70	1,428	1-80	1,250
Lysol	1-90	1,111	1-100	1,000
Phenoloid A	1-150	666	1-200	500
Phenoloid B	1-150	666	1-200	500
Chlorinated lime (32% available chlorine)	1-1600	62	1-2000	50
Mercuric chloride	1-6400	15	1-10000	10

B. Suspension Method.

Test microbe B. typhosus grown for 24 hours in peptone bouillon (+5) at 37° C. Solution of phenol prepared with distilled water. $\frac{1}{20}$ cc. of culture added to 10 cc. of phenol solution.

Temp., 17° C.
Time of exposure, 10 minutes.

	Minimum lethal dil. observed.		Maximum non-lethal dil. observed.	
		Parts per 100,000.		Parts per 100,000.
Boric acid	1-80	1,250	1-90	1,111
Phenol	1-200	500	1-300	333
Lysol	1-500	200	1-800	125
Phenoloid A	1-500	200	1-800	125
Phenoloid B	1-2000	50	1-3200	31
Chlorinated lime (32% available chlorine)	1-3200	31	1-6400	15
Mercuric chloride	....	....	1-20	5,000

The figures given in these tables are each based upon the results of five simultaneous tests made with five consecutive dilutions. Beyond thorough washing and shaking and use of large quantity of nutrient fluid no attempt was made to neturalize the action of any of the disinfectants at the end of the exposure.

429.

Nissen, F. *Ztschr. f. Hygiene,* Vol. 8, p. 62, 1890.

This important work was conducted at the Hygienic Institute of the University of Berlin, and gives a full record of experiments on B. typhosus, B. choleræ, and the bacilli of anthrax, staphylococcus pyogeneus aureus, streptococcus erysipelates, the spores of anthrax, as well as trials with feces which had been infected with B. typhosus. Lethal doses and time factors are given in comprehensive tables from which we quote:

Organisms killed.	Minutes.	By dilutions of chloride of lime.
B. typhosus	1	1: 800
B. typhosus	10	1: 1600
B. choleræ	1	1: 800
B. choleræ	10	1: 600
B. anthracis	1	1: 1000
B. Staphyloc. p. aur	5	1: 800
B. Streptococcus, erisypal	1	1: 200
B. Streptococcus, erisypal	5	1: 700
Spores of anthrax	15	1: 20
Spores of anthrax	20	1: 100

In a 5% chloride of lime solution to which hydrochloric acid had been added anthrax spores were killed in two minutes.

In steam sterilized feces, infected with typhoid bacilli, chloride of lime destroyed the pathogenic germs with from two to ten minutes under varying conditions when present to the amount of 1: 200 on the mixture.

430.

WORONZOFF, WINOGRADOFF and KALESANIKOFF in the Report to the Russian Minister of the Interior (*Centralbl. f. Bakteriolog.* Vol. 1, No. 21, 1887) state, that anthrax spores are killed in a 5% solution of chloride of lime within one minute, while 2.5% solutions did not kill the spores in one minute.

431.

JAEGER, H., reports in the *Arbeiten aus d. K. Gesundheitsamte*, Vol. 5, p. 247, 1889, on a series of infections of animals by means of pure pathogenic cultures which had been treated with chloride of lime. Dr. Jaeger sums up: Among the disinfectants employed in these investigations chloride of lime stands in the first rank as germicide.

432.

Engineering Record, Vol. 64, p. 733–734, 1911.

433.

Engineering Record, Vol. 63, p. 264–268, 1911.

434.

JENNINGS, C. A. *Engineering Record*, Vol. 63, p. 665–667, 1911.

435.

Engineering Record, Vol. 59, p. 771, 1909.

436.

Engineering Record, Vol. 63, p. 113, 1911.

437.

Engineering Record, Vol. 63, p. 293–294, 1911.

438.

Annual Report of the State Board of Health, State of New Jersey, 1910.

439.

Engineering Record, Vol. 65, p. 555–556, 1912.

440.

RACE, JOSEPH. *Jour. Society Chemical Industry*, Vol. 31, p. 611–616, 1912.

441.

Engineering News, Vol. 65, p. 634, 1911.

442.

Engineering Record, Vol. 64, p. 516, 1911.

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INDEX.

The index is divided into two parts, a subject index and a name index. The subjects in the text portion of the book only are listed in the former. The subjects in the abstracts are classified under headings listed in the Table of Contents on page iii to which the reader is referred. In the name index references are given to every person mentioned throughout both sections of the book. Mention of use, production or composition will be understood to refer to chloride of lime.

SUBJECT INDEX.

NAME INDEX.